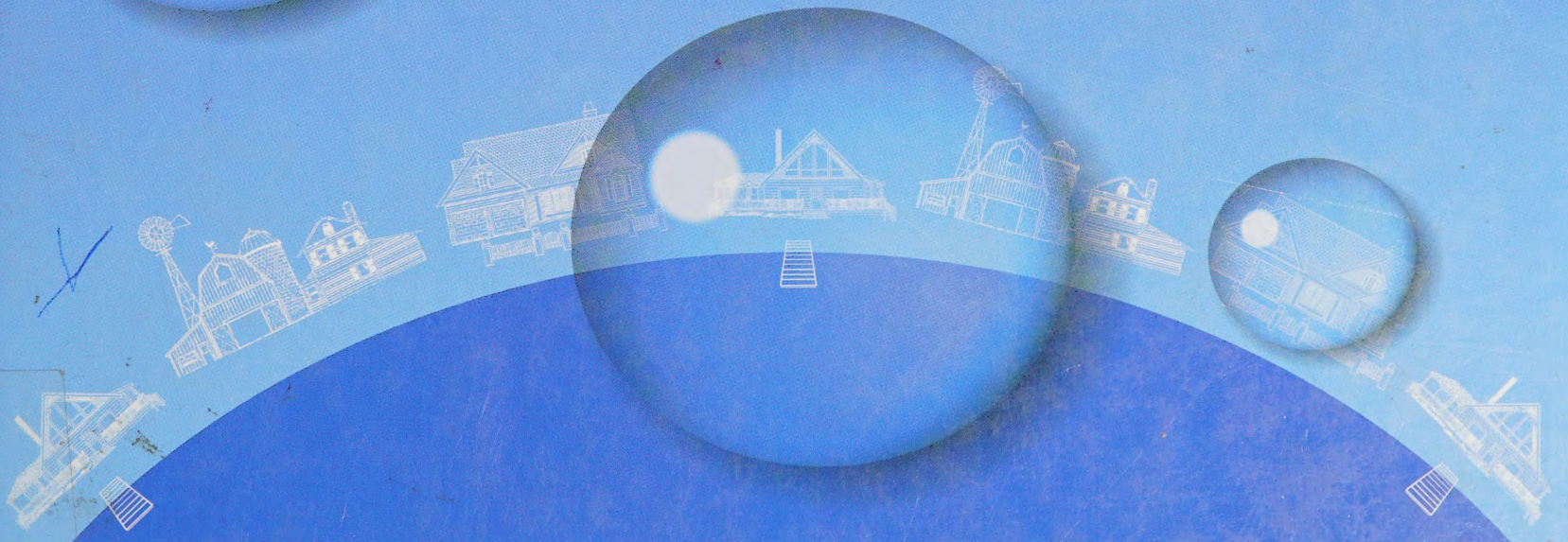


**A COMPLETE OUT-OF-THE-CITY GUIDE TO ON-SITE WATER & SEWAGE SYSTEMS
INCLUDING PUMPS, PLUMBING, WATER PURIFICATION, & ALTERNATIVE TOILETS**



COUNTRY & COTTAGE WATER SYSTEMS



BY MAX BURNS

COUNTRY & COTTAGE
**WATER
SYSTEMS**

A Complete Out-of-the-City Guide
to On-Site Water & Sewage Systems
Including Pumps, Plumbing, Water
Purification, & Alternative Toilets

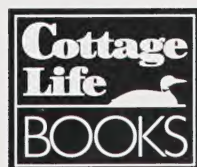
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MAX BURNS





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Library and Archives Canada Cataloguing in Publication

Burns, Max, 1948-

Country & cottage water systems : a complete out-of-the-city guide to on-site water & sewage systems including pumps, plumbing, water purification & alternative toilets / Max Burns.

Prev. ed. publ. under title: Cottage water systems.

Includes index.

ISBN-13: 978-0-9696922-7-0 ISBN-10: 0-9696922-7-7

1. Water-supply, Rural. 2. Water--Purification.
3. Plumbing. 4. Sanitation, Rural. I. Title.

TD920.B87 2010

628.7

C2010-902304-8

Published by Cottage Life Books

54 St. Patrick St.

Toronto, Ontario, Canada

M5T 1V1

www.cottagelife.com

Trade distribution by

Firefly Books Ltd.

66 Leek Crescent

Richmond Hill, Ontario

L4B 1H1

Printed in China

Publisher Cataloging-in-Publication Data (U.S.)

Burns, Max.

Country & cottage water systems : a complete out-of-the-city guide to on-site water & sewage systems, including pumps, plumbing, water purification & alternative toilets / Max Burns.

[] p. : ill. (chiefly col.) ; cm.

Includes index.

Summary:

ISBN-13: 978-0-96969-227-0 ISBN-10: 0-9696922-7-7

1. Water-supply, Rural. 2. Water -- Purification. 3. Plumbing. 4. Sanitation, Rural. I. Title.

628.7 dc22 TD920.B8767 2010

Published in the United States by Cottage Life Books

Box 1338

Ellicott Station

Buffalo, N.Y., U.S.A. 14205

www.cottagelife.com

Trade distribution by

Firefly Books (U.S.) Inc.

P.O. Box 1338

Ellicott Station

Buffalo, N.Y., U.S.A. 14205

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Illustrations by Neil Stewart and Dave McKay

Cover illustrations by Neil Stewart

Edited by David Zimmer

Design by Amal Jama; Steve Manley, Overleaf Design Ltd.

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The reference material in this book was drawn from brochures, products, and information bulletins provided by a number of companies, associations, government sources in both Canada and the U.S., and the author himself. Thanks to Beatty Pumps, *Cottage Life* Magazine, Cottage Water Supply Ltd., Diverse Plastic Tanks Inc., Dow Chemical, DSMI Air and Water Purification Products, Envirogard Products Ltd., F.E. Myers, Co., Goulds Pumps Inc., GSW Water Products Co., Heat-Line Corp., Incinoleet Inc., Infiltrator Systems Inc., Jacuzzi, Koenders Windmills Inc., Nimbus Water Systems Inc., Orenco Systems Inc., Pentair Water Treatment, Philmac Valves and Fittings, Polar Bear Water Distillers Mfg. Co. Ltd., Premier Tech Environnement, Rainbow Concrete, Rintoul's Hand Pumps (Guzzler, Oasis, Sigma), Sancor Industries, Sanitary For All Ltd., Separett AB, Sun-Mar Corp., Waterloo Biofilter Systems Inc., Water Quality Association, Wedco, and all the various government agencies who gave of their time and information. Apologies to any we missed.



Congratulations!
You are now an
owner-operator

Local regulations
may vary

Ignore the
bafflegab

Go for the best

INTRODUCTION

Demystifying on-site water and sewage systems:
New technologies and new solutions



COUNTRY & COTTAGE WATER SYSTEMS has one primary objective – to demystify the workings of on-site water and sewage systems. On-site systems are the ones not connected to municipal networks, the private water and sewage systems those of us who opt for rural life depend on, whether as an intrinsic part of a year-round residence or a seasonal vacation home. We are the owner-operators of these systems and shoulder full responsibility for their care and upkeep. To succeed in that role, a good understanding of the design, the workings, and the maintenance of the systems – at least enough understanding to know who to call when a system fails – is a must. (Better yet, we should know who to call to keep it from failing in the first place.) The purpose of this guide is to clearly explain a myriad of options available for water and sewage system solutions, helping you choose the system best suited to your situation, location, and budget. It will also teach you about maintenance and repairs, a sometimes dirty job even the most reluc-

tant of us might be conscripted into performing when a tradesperson is not available and things need to be fixed, right now.

The first edition of this guide, titled *Cottage Water Systems*, hit the bookstores in 1993. And while the original book contained no misinformation, as the years and decades passed, it became increasingly apparent that it was missing information. New discoveries, new solutions, new problems, and even new science was beginning to date the book. The other thing that became apparent was that many of the guide's readers were not technically cottagers, but instead folks much like myself, who live in a rural setting year-round. Bearing that in mind, with the exception of the seasonal opening and closing rituals of a typical cottage, everything within this version has been designed to apply to either situation. As a result, while cottage-oriented content has increased, so have the year-round solutions for country dwellers. Hence the new title, *Country & Cottage Water Systems*.

Another important recognition was that more and more rural folks are opting for off-the-electrical-grid solutions, either by choice or by circumstance. So this guide also includes more water and sewage system solutions for them, too. (Note: Alternatives for producing electricity are not included here, that topic being beyond the scope of this book.)

Regardless of the situation, the effectiveness of any water supply or sewage system is largely dependent on the owner-operator's vigilance. You, in other words. You are the one responsible for the system's effectiveness, and hence the related welfare of its primary users – yourself, your family, and your guests. So it makes sense to do the job right the first time rather than skimping a little here and there just to “save a few bucks.” It's a philosophy that will be repeated throughout this guide. No question, *Country & Cottage Water Systems* will help save money, but not by compromising standards.

Just like the first edition, *Country & Cottage Water Systems* is not simply a how-to guide, it's also a “why?” guide. It has always been my belief that given the reasoning behind any decision – the “why” – folks are more inclined to do the job right than if simply instructed to perform some esoteric task. Knowledge converts the drudgery of work into understanding. Understanding puts you in control, which is where any owner-operator should be.

A few notes and caveats

Books on basic plumbing abound, and some are even worth reading, yet plumbing as it pertains to country and cottage living has, for the most part, been only given a cursory look at best. In this guide, it's that overlooked part that gets the emphasis. So some of the details on basic plumbing are not addressed.

In this edition, cottagers are defined as those who vacation in a rural setting, most often adjacent to a body of water. Country folk, or ruralists, are those of us who live in a rural setting year-round.

Because this topic encompasses such a wide geographical region, it's impossible to take into

account all jurisdictional regulatory variations. Instead, we opt for the highest common denominator, providing solutions that offer the least environmental impact whenever possible. Yet even this standard is often based on the minimum standards of the more progressive jurisdictions. And minimum standards yield minimum acceptable results. The financial cost of exceeding those minimums is often negligible, even from my sedentary wallet's point of view, so go for the best you can afford. Less expensive is no bargain if it doesn't do an effective job over an acceptable period of time.

Don't purchase any piece of plumbing equipment, make any alterations to a water or sewage system, dig any holes, or sign any contracts without getting prior regulatory approval regarding use and installation, preferably in writing. Some of the things discussed in *Country & Cottage Water Systems* may contravene regulations in your locale, but with so many varying laws this, regrettably, is unavoidable. And it may be necessary to get approval from several levels of government agencies, such as those responsible for the environment, natural resources, conservation, public health, navigation of waterways, and the welfare of fish. Don't forget the authorities for building, plumbing, electrical codes, and local by-laws. Hard to believe so many government bureaucrats could be so interested in your family's toilet etiquette, but sometimes that's what it takes to flush out potential polluters.

Buy only from knowledgeable sources that specialize in the product or service you require. This greatly increases the odds of success. Also, remember that membership to relevant trade associations can be an indication of professional competence but it's no guarantee. Sometimes, affiliating with a recognized association merely provides an honourable shield for shysters to hide behind. So get references from people capable of judging the particular skills or services of the company or person involved. After many years of dealing with retailers and tradespeople, a few with ethics that would embarrass a politician, I have developed this simple rule for character judgments: Never deal with anyone who

talks faster than you can think. It's a rule that only fails me when I ignore it.

The world has become polluted with product names prefaced with such virtuous catchwords as Eco, Bio, Enviro, et al, the implication being that each product is somehow a great and wonderful friend of planet earth. Some are. But many are simply riding the eco-bio-enviro-coat-tails of the good guys. And on a related note, how do brochure pictures of near-naked babies clinging to stuffed toys while swaddled in white bath towels attest to a water or sewage system product's superiority? Ignore the name, ignore promotional song-and-dance routines, and judge only the worth of the product.

My aim is to provide you with as much knowledge as possible within the confines of an easy-to-use, and easy-to-read, guide. But remember, this is just a guide; it cannot provide detailed answers for every possible situation. Even then, I will attempt to point the reader in the right direction to find those answers. As a longtime owner-operator of an on-site water and sewage system, an occasional installer of both, and a longtime student of the subject who has written about it for all those years (this is making me sound awfully old), it has always been my goal to seek out systems that work, with minimal impact on the planet and at least an acceptable impact on the wallet. This guide is a culmination of that effort and I have enjoyed putting all the pieces together. I hope you find it just as rewarding to read and to use.

Can we drink it?

Surface water

Rain collection

How to locate
groundwater

Types of wells

Natural springs

Recommended
setbacks

Storage systems

Avoiding well
pollution

2. SOURCES OF WATER

How to tap into all the options

WATER IS A FINITE RESOURCE. It doesn't cease to exist when it flows downstream, or gets poured down a parched throat, or evaporates whenever a puddle dries in the sun. No, it just ends up someplace else, perhaps in a lake, or a cloud, or simply hanging around inside some organism – you, for instance – waiting for its next move. So water is the consummate wanderer, showing little allegiance to any particular home, no telling where it's been before you had your way with it. Kind of gives a whole new meaning to the concept of “fresh water,” doesn't it? In all probability, you're drinking and bathing in used water. And, depending on where we live, that can happen a lot.

North Americans use almost three times as much water per person as folks living in Europe. That said, those of us who live free of the municipal water/sewage grid tend to use less than those tied into that central tap and toilet. We often have fewer appliances to feed, lawns to water, and vehicles that need frequent clean-

ing. And maybe there's a more relaxed attitude towards hygiene in the country, but some people even tend to wash less frequently. (Granted, showers are often replaced by a dip in the lake, or a wash in an outside basin.) From an environmental standpoint, this is all good news – we use less water and nature has to cope with less of our waste. Reduced demand also offers us another interesting benefit: Cottagers and ruralists can choose from a number of options for their water source, including lakes, rivers, rain collection systems, springs, and a variety of well types, or even choose to haul the stuff in.

Some of these water sources may not be on the menu of legal options for your situation. Regulations governing water sources vary widely, so check to ensure that your preference is acceptable to local authorities. Local laws may also determine how much of the work you can do yourself, while some jurisdictions insist that only licensed tradespeople work on water systems. Those restrictions aside, this book considers water sources

even remotely within the grasp of an industrious do-it-yourselfer as DIY. Should you opt to do it yourself, most jurisdictions have information sheets and booklets that can make the job of conforming to local laws much easier. (Keep in mind that, in theory at least, the object of these laws is not to prevent you from doing something wrong, but to assist you in doing it right.)

WHERE'S ALL THE WATER?

It's pretty much impossible to measure the earth's inventory of water accurately, but guesstimates abound. The good news is that most of the earth's surface is covered in water. You can see that for yourself by looking at a globe or some satellite's view on the internet. The bad news is that less than 3% of all the earth's total water sources is both fresh (unsalted) and available for human consumption. This pittance, the portion allotted to us for drinking, washing, and the other uses we've labelled as necessities, comes from two main sources: surface water and groundwater. Surface water is what we see – the lakes, rivers, ponds, streams, and wetlands that are so much an integral part of the rural landscape. Yet it accounts for a paltry 0.3%–2% of that meagre freshwater quota, the vast majority being frozen in glaciers or polar ice caps (about 74%) or hidden as groundwater (25%, give or take). There's also an additional smidgen hanging around in the atmosphere. Accessing the water in glaciers and ice caps is even more difficult than accessing a government help line by phone. And unlike government employees, ice caps and glaciers are diminishing, our changing climate causing the ice to melt, often into a nearby ocean to become unusable by humanity as it mixes with salt water. Groundwater is our undercover resource, lurking beneath the earth's surface in unseen, underground reservoirs called aquifers. These aquifers feed our wells and springs and in many cases help to replenish surface-water supplies.

But none of it is new water, it's just relocated water. So regardless of source, the immediate and continual availability of water is restricted by how quickly the supply can replenish itself

whenever we tap into it, what geologists refer to as the recharge rate. In some areas, nature can be very stingy in doling out its water, rewarding us with no reliable surface water or groundwater, and very little rain or run-off from higher elevations. When total demand from all forms of life exceeds supply, the result is a drought.

Humans – a species seemingly bent on proving itself smarter than nature – will often just tap deeper into the earth in search of additional groundwater but that, too, is limited by the recharge rate. Take too much – whether for personal use, business, or agriculture – and all that's left is a big underground void, one that can collapse in on itself from the weight above, as witnessed in some areas of southern Florida. Alternatively, that void can also be recharged by more distant ocean waters, filling the hole with unusable salt water, an event that has occurred in a few coastal regions around the world. And of course, sometimes we turn good water into bad, converting what we could have enjoyed straight from a glass into toxic and pathogenic waste that nothing wants to consume or live in. Rather than stupidity, we call this pollution, perhaps to make us feel better about ourselves.

SURFACE WATER (DIY)

Because of its exposure to both nature's and humanity's outpourings, surface water is easily polluted. Even in the remotest areas of the country, animals bathe and defecate in it, vegetable matter decomposes in and around it, and pollutants merge with it every time it rains. In more populated areas, there's run-off from farms, golf courses, and private lawns. Perhaps an upstream industry with bad hygiene has been pumping all sorts of nasty things back into the mix. And don't forget boats in the summer and snowmobiles in the winter. In other words, today's tasty aquatic treat could be tomorrow's toilet.

But this vulnerability isn't all bad news. Nature does tend to cleanse its surface waters, using the wind, sun, and earth to work at mitigating the damage through evaporation and filtration.

Unfortunately, the cleansing process is often overwhelmed by the sheer quantities of contaminants surface water has to deal with. The only thing you can count on is that the constituents of surface water will vary. Consequently, *no* surface water should be considered potable without appropriate treatment. (See Chapters 5 and 6.)

Yet it would be wrong to automatically inflict some sort of “Caution: For Recreational Purposes Only” label on surface water. For instance, untreated surface sources can often provide

vide water for our non-drinking needs. Surface water is also tough to beat for handiness – for many cottages, and some rural homes, it’s right out the front (or back) door. All that’s needed is a bucket. With a bit of hose and a pump, we can even get it to flow into the kitchen. Which explains why it’s the traditional source of water in cottage country.

Obviously, some cottagers and most ruralists lack ready access to those traditional, and often prolific, sources of surface water – lakes and rivers. So it’s a good thing water likes to wander, often travelling as rain.

WARNING: MATH AHEAD

How much water can you expect to collect from a typical roof? With a tape rule in one hand and a calculator in the other, measure the catchment area (usually the roof, measured across the flat, not the pitch) to get the area in square feet. Next, you’ll need to know the amount of expected rainfall in a given period. Average rainfall statistics, annual and sometimes monthly, are available from local weather offices. You can verify if the statistics match the rainfall of your site by leaving a large juice can out in the rain, recording the level after each rainfall (or when convenient), and adding it up for the period observed. Then choose the lower figure of the two just to play it safe. You also need the assumed amount of water capable of being collected, usually arbitrarily pegged at 600 US gal. (230 L), and the collection efficiency rate. In a perfect world, that rate would be 100%, but because some of the rain overshoots the eavestrough, and some will be lost in roof washing, and some just won’t cooperate and run off the roof at some other location, most estimates place efficiency at about 75%, but feel free to adjust that to suit your situation. Next, apply these figures to the following handy-dandy formula:

**(catchment area) x (inches of rain) x (600 US gal.) x (0.75),
the product divided by 1,000.**

An example: Your building has a pitched roof, and you’ve decided to collect the water from one side only. That side measures 20 ft. by 32 ft. So the catchment area equals 640. Rainfall for the month worked out to, say, 1.5 inches. So $(640 \times 1.5 \times 600 \times 0.75)/1000 = 432$ US gal. of water; multiply by 3.785 to convert to litres should your prefer to drink in metric. Or, for a totally metric calculation that yields almost the same answer, 30 cm of rainfall yields about 19 L per 0.09 square metres of roof area (12" yields 5 US gal. per square foot).

Obviously, rainfall is a variable, all year. By calculating the amount you are theoretically able to collect during both wet and dry seasons, you will get a good idea as to how large a storage container is needed to gather sufficient water during the rainy season in order to see you through the dry spells.

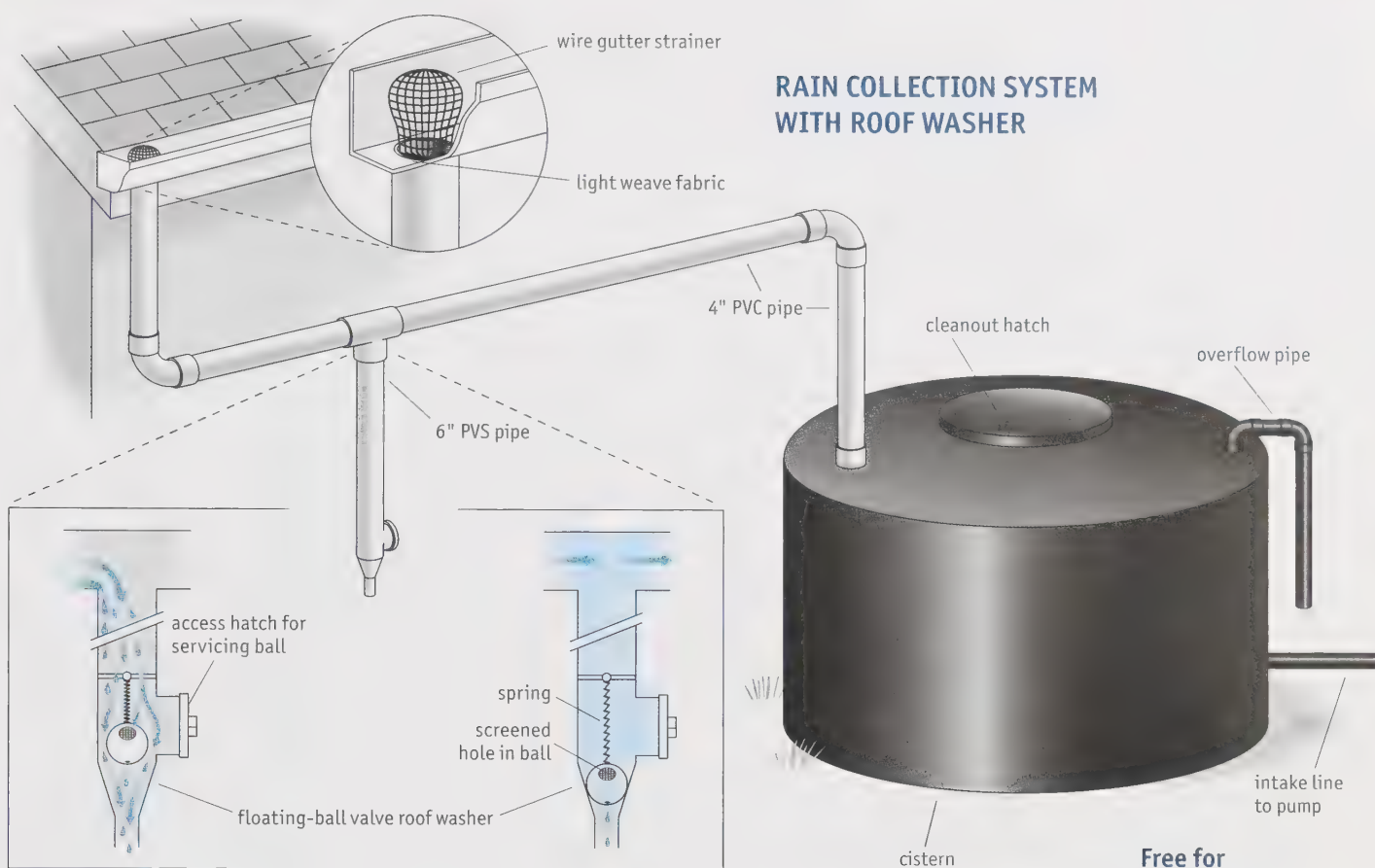
RAIN COLLECTION

Because rain is basically surface water in transit, it’s part of the surface-water repertoire. Therefore, many of the same potential pollution problems that exist for lakes and rivers apply here too. Implicit with that similarity is the need for such water to be treated before it can be considered safe to drink, though it could always be reserved for non-drinking needs.

Who would have thought the collection of rainwater needed banning? Colorado for one, where as of this writing it is illegal to harvest rainwater. So, as always, check with local authorities for permit or design requirements before you begin.

The basic system for collecting the runoff from a roof and delivering it to a storage container begins with standard-issue eavestrough. The water flows into the trough and drains down the spout into a storage container below. For this reason, containers filled by rainwater must have some method of catching all the crud that washes off the roof.

For the bigger stuff, begin with a gutter strainer where the trough meets the downspout, followed by a secondary filter directly below. This filter can be homemade; a scrap of light-weave fabric will do in a pinch, stretched over the opening, preferably on an angle to allow for some modest self-cleaning action. Fortunately, ready-made filters, and even plans for suitable containers, can be purchased. Next, you’ll want a nifty gizmo



Free for the taking:

Simple rain collection systems channel roof runoff into a storage reservoir. Must-have features include a gutter strainer and a secondary filter (to screen out the big stuff) and a roof washer or "first-flush system" to divert the initial rainfall away from the cistern. This ready-made version employs a nifty float-ball system to keep that first wash – and its dirty payload of pollen, mould, and bird droppings – from reaching the water supply.

known as a roof washer or first flush system. (In some jurisdictions, such devices are mandatory.) There are a number of types to choose from, some homemade, some ready-made, all working on the same basic principle: divert the initial runoff away from the storage container. It's that first wash that carries the worst of roof contaminants, typically a varying concoction of pollen, mould, moss, fungi, algae, and bird droppings travelling with the water. Yum.

With the simplest of roof washers (the easiest version to fabricate yourself), rain water travels down the 4"-6" downspout at an eavestrough's terminus to a 90° elbow that redirects the flow along an almost horizontal pipe of the same diameter. This pipe maintains a very modest slope en route to the storage container. Along this horizontal run, one or more pipes of the same diameter drop down from it via T-junctions. These drop pipes are either sealed with caps or connected together to form a U-shaped run suspended below

the horizontal run. It's these down pipes that do the dirty work.

When the rain starts, the down pipes fill up with the initial runoff that carries most of the crud. Once full, the remaining, and hopefully cleaner, runoff flows over the filled pipes directly into the storage container (or through yet another filter on the way there). Typically, a small hole near the bottom of the down pipes allows them to self drain and ready themselves for the next rainfall (though you'll still have to uncap the pipes and clean the crud out now and then). Another system lending itself well to the DIYer is the self-draining sediment basin. The basin, a capped container about two feet square (depending on rain volume), is filled with sand and gravel, which soaks up the initial dirty runoff. Once the basin is full (the sand and gravel preventing the water from rushing directly out the bottom drain), the overflow spills out the top into the pipe running to the storage container.

One interesting ready-made roof washer incorporates a floating ball valve housed in a tapered down pipe, the ball suspended on a spring. As the initial rush of rainwater enters the downpipe, it passes around the ball to fill the pipe. At the same time, some of that water also flows into the ball through a screened hole in its top. As the ball gradually fills, it becomes heavier, sinking to block the downpipe. With the downpipe both full and blocked, the rainwater now heads directly for storage – just as it does in the system above. The wash water drains out a small hole in the bottom of the pipe, and another, smaller hole in the ball lets the water slowly drain out of it, allowing the ball to rise and open the valve, preparing the system for the next influx of water. The potential advantage to this system is that the amount of water entering the ball can be adjusted via the size of its screened hole, altering the time it takes to begin its descent. This allows

the roof washer to match varying conditions, such as infrequent bursts of heavy rain or gentle rains that fall often.

GROUNDWATER

While it's true that systems drawing from groundwater sources rather than surface water sources are more reliable and don't require the same level of seasonal cold-weather preparations, the principal motivator for choosing groundwater as a source for drinking water remains concern over water quality. Simply put, groundwater is less susceptible to contamination.

Groundwater, hidden away in underground aquifers, is the source of drinking water for about half the population of North America. Aquifers can be pockets of porous earth that hold water much as a sponge does, or fractures and under-

STORAGE SYSTEMS (DIY)

Cisterns, reservoirs, and rain barrels usually depend on rainfall for supply. Yet for those coping with low-yielding wells, or drought, the added reserve of a storage system can be a welcome relief, whether for household use, gardening, or even fire fighting.

To help keep pollutants out, the storage container must be watertight, the inlet and outlet providing the sole points of entry and egress. Its interior surface should be smooth and nonabsorbent to discourage various aqua-creeps (such as algae and pathogenic microorganisms) from collecting in cracks and crevices. Pay particular attention to the openings for cleaning, filling, and draining, as rough joints can be breeding grounds for the aqua-creeps. And any container should be easily accessible for cleaning.

Concrete, parged concrete block, steel, or plastic are all acceptable materials for water-storage tanks. Concrete-block tanks, and in most cases poured concrete ones as well, are constructed on site. Steel containers can also be custom fabricated to suit your particular need, or purchased ready-made. Plastic

containers are ready-made, either in fiberglass or high-density polyethylene (HDPE). Wooden rain barrels, the choice of romantics, regrettably make swell homes for microorganisms. So treat any water stored in wooden containers before drinking it – even if you've collected the water from a potable source.

Because of its durability, affordability, and modest weight, the HDPE tank has become the preferred choice. It comes in a seemingly endless variety of shapes and sizes, and can be installed above or below ground. Some are designed to fit perfectly in the bed of a pickup, just behind the cab, for easy frequent transport of smaller quantities (e.g. American Tank Co.), while others store nicely in the usually wasted space under the typical 54" mattress and box spring (e.g. Diverse Plastic Tanks). Because HDPE containers are often marketed for agricultural use, stores serving farming communities will sometimes keep a few in stock.

Unless they've been certified as food-grade containers, do not use recycled steel drums or plastic barrels for duty anywhere near water because of the high

ground caverns in rock. Aquifers can be isolated tankards or an interconnected series of reservoirs that can extend for miles. Some aquifers lie just a few feet below the surface, with their water levels being topped up every time it rains. Rainwater being naturally soft and acidic, and therefore slightly corrosive, absorbs soluble minerals from the rock and becomes harder as it percolates through earth. Simultaneously, microorganisms and many harmful chemicals accumulated from the atmosphere and initial contact with the earth's surface are gradually left behind as the water continues to filter downward. This tendency for water to swap contaminants with earth usually increases in proportion to the depths it must travel before joining up with a suitable aquifer, so deeper is considered better from a quality standpoint. And the deeper the aquifer, the more likely its contents will be unaffected by rainwater and whatever else is happening on the surface.

In fact, it's quite possible for aquifers to lie undisturbed for millennia. Either way, it's this natural cleansing process and relative isolation that makes groundwater a safer and more consistent source of potable water than surface water. That said, once polluted, groundwater will likely remain that way for a very long time. How does it get polluted? Usually via some connection to the surface, such as a spring or a well.

When the weight of the earth above an aquifer exerts a force on the water within it that is greater than atmospheric pressure, that water will rise whenever a connection is made, whether that connection is naturally occurring or one constructed by us. Normally, this simply brings the height of the water closer to the surface but if the pressure is great enough, water will pour out that connection's exit as if someone left the tap running. We call this an artesian spring or flowing (or artesian) well.

risk of residual toxic chemicals leaching into the water. (This warning applies whether the intention is to store the water inside the drum or use the drum to support a raft or floating dock.)

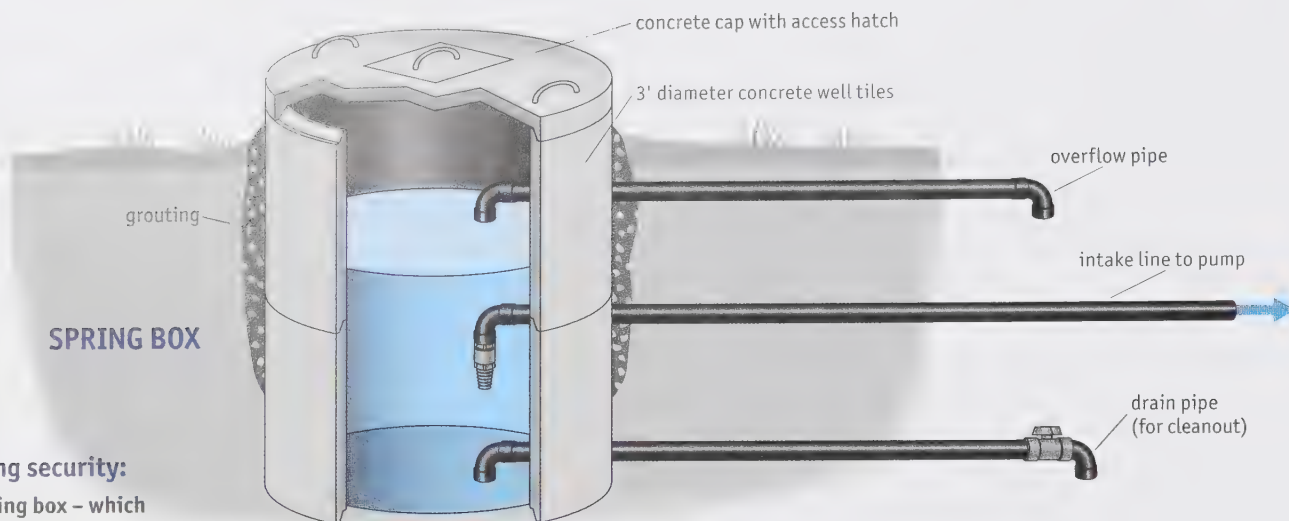
The size of the container required depends both on your water needs and on how quickly the container can be replenished. Some jurisdictions have a minimum requirement of 5,000 US gal. (19,000 L) for water-storage containers serving full-time residences. Assuming your area isn't governed by such restrictions, careful consumers not disposed to city-style water consumption should be able to cope quite nicely on a 250–600 US gal. (1000–2300 L) tank.

Regardless of container type or size, all outdoor water containers should be covered in order to keep out animals and their various droppings, not to mention natural debris with a penchant for drifting into any container's open end. This closed-door attitude also discourages enterprising mosquitoes from converting your water supply into an insectile maternity ward. Outdoor drains and vents for water-storage containers

should be noncorroding – brass or plastic for instance – and be screened to prevent nature's non-micro miscellanea, such as rodents, bugs, and leaves, from getting into the stored water.

If you're using a pump to move water out of the container, place the pick-up point for the intake line about 12" (30 cm) above the container's floor to avoid sucking in settled debris. It's also a good idea to attach a float-activated shut-off switch to turn the pump off should demand exceed supply, thereby avoiding the ominous (and expensive) fragrance of fried pump.

Raised storage containers, such as water towers or reservoirs for hillside springs, can provide pressure for a water system, eliminating the need for pressure tanks and perhaps even a pump. Every 2.31' (70.5 cm) up – measured from the tap to the water's surface – rewards us with 1 psi (pounds per square inch) of water pressure. In other words, a 30' (9 m) high water tower would yield $30 \div 2.31$ or 13 psi, enough pressure to fill a toilet or a sink or enjoy a pretty pathetic shower (but a shower nonetheless).



Spring security:

A spring box – which is essentially a cistern sitting at the spring mouth – protects the water from surface pollution. They can be economically constructed from standard concrete well tiles.

SPRINGS (DIY)

Spring water has the reputation of being the cat's meow, but in reality, it can be closer to some of the other things a cat emits. While it's true that water loses many of its worldly contaminants en route to finding an aquifer, if the return trip to the surface is unprotected there's little to stop contaminants from rejoining the flow. A well has a lining or casing to help protect it; a spring has nothing. Therefore spring water almost invariably must be treated to ensure it's safe for drinking.

There are two types of springs: gravity-fed springs, which are most often found flowing from a hillside; and artesian springs, which are fed by an aquifer under pressure. Artesian springs are less likely to stop running during dry spells and are less prone to pollution (but not immune to it).

BUILD A SPRING BOX (DIY)

Contamination at the surface – from animals stopping by to take a drink and maybe drop off a contribution – can be curtailed by building a spring box. This “box” is essentially a cistern or dug well sitting at the mouth of the spring, complete with lid. But rather than being fed by surface water, it's fed by the spring. Therefore, it shares many of the same construction criteria, though you'll want to check with local au-

thorities regarding any additional restrictions in your jurisdiction. Well tiles, 3' (1 m) in diameter, make for an economical spring box, one reason I chose them to box the artesian spring on my own property. Be forewarned, these tiles are extremely heavy – even Waldo, my aged backhoe, had trouble lifting them into place. Those without backhoes should have a good cache of friends to call upon come time to manoeuvre the tiles into place. (The main advantage to the backhoe, of course, is that it doesn't come with accompanying advice.)

In common with the dug well, a spring box will usually have an intake line running through the wall of the box to a pump, but with or without this luxury, it will need a screened overflow – a pipe terminating away from the area surrounding the spring – to reduce soil erosion near the box. Drainage ditches dug uphill of the spring to divert surface runoff away from the area will also reduce the potential for pollution.

WELLS

For those without a handy spring, the only way to reach an aquifer is by way of a well, a vertical shaft either dug, driven, jetted, bored, or drilled into the ground. Well diameter is largely dependent on well type, while the depth is dependent

on how deep the aquifer is and the volume of water that aquifer can produce, measured in gallons or litres per minute or hour.

The protected environment of a well keeps both animals and people away from your water and intake line. Drawing water from a well usually allows you to bury the intake line, a luxury for most cottagers as it eliminates many of the annoying jobs that tend to dominate seasonal openings and closings when drawing water from lakes and rivers. And it can end worries for both cottagers and ruralists over whether this year's ice will tear the intake line apart, the line safely buried rather than left in situ at a shoreline.

But the greatest advantage a well has over surface water is the potential for consistent water quality – whatever's in the water today is likely going to be in there tomorrow. This makes treating the water much easier – if treatment is required at all.

The downside to wells is the labour and costs involved in construction. And even after having spent the time and money, there's no guarantee that water will be found, or that the aquifer will have sufficient yield, or be potable. However, there are indicators which at least give us hints as to the location, quantity, and quality of nature's buried treasure.

HOW TO LOCATE WATER

For many areas of planet earth, geological and groundwater surveys can be obtained from government sources. Using these surveys, hydrogeologists or persons similarly inclined can offer a scientific point of view as to whether there might be groundwater in your area, and at what depth. That said, neighbourhood wells are often better indicators, particularly of water quality, as are local well drillers who may be familiar with conditions in your area. Well installers' records may also be available for recently constructed wells, revealing such things as GPS location and well performance data, such as depth and the water's willingness to get pumped out into our taps.

Keep in mind, however, that wells may be where the expression "There are no guarantees

in life" originated. The well driller my nearest neighbour chose had just finished two wells a bit south of us. The two are not more than 300' (90 m) apart. The first measures a little more than 200' (60 m) deep, the second a tad over 100' (30 m). My neighbour ended up with a hole drilled 290' (88 m) down into bedrock before a suitable aquifer was found. All three wells have plenty of water, and the quality is first-rate. About 330' (100 m) from my neighbour's deep well sits my artesian spring, 6' (2 m) deep. Across the road, another neighbour dug a new well and hit plenty of good water about 30' (9 m) down. Such is the often unpredictable nature of aquifers.

WATER WITCHING (DIY)

One ancient method of locating that elusive aquifer is witching, also known as dowsing, divining, or a bunch of hooey-balooley. There's no basis in science for this practice, but since the same could be said for a lot of things humanity embraces as fact, it's worth considering. Albert Einstein, a man smart enough to know that we don't know everything, agreed: "The dowsing rod is a simple instrument which shows the reaction of the human nervous system to certain factors that are unknown to us at this time." That simple instrument, referred to as the dowsing rod, divining rod, or witch, is a Y-shaped implement about 12" (30 cm) long at the bottom of the Y, the two upper branches each being about 16" (40 cm) long, though that's not set in stone. But neither is the rest of the hocus-pocus. The rod can be anything from a willow branch to a pair of rusty coat hangers (I'm not sure if the rust is essential), and there are as many methods of holding it as there are crooked politicians.

When I was considering digging a new well, I called on neighbour Jürgen because he claimed to have once witched and found water. Jürgen's also a traditionalist. He insists the rod be cut from a suitable tree growing in the area to be witched, and is particular about the manner in which the witch is held. With forearms bent at the elbows and held out in front, hands palm-side up, you clasp the forks of the Y, the

end of the Y pointing outward and slightly upward in front of you. Then you walk around the yard with this backwards slingshot in your hand, hoping no one who hasn't read this will stop and ask what the heck you're doing.

Jürgen and I headed off in different directions, not wanting the findings of one witcher to influence the other. About a half hour into our choreographed tramp about the yard, the end of the puny Y-shaped stick suddenly pulled at my arms, pointing to the ground with alarming force. The intensity of this hyperactive wand was such that it strained muscles trying to hold onto it. I was dumbfounded, unable to do anything but laugh as some of the red in my neck found a more appropriate home in my face.

Jürgen came over and, without knowing the location of my find, confirmed the results with his witch. So we fired up Waldo, the backhoe, and went digging. Voilà, water. The only thing missing was the scientific explanation, not to mention a house or building within easy reach of this newly discovered source of water. But I can't fault the witching for that.

Custom has it that not everyone is capable of witching. For instance, during the witching spree at our property neither my wife nor my son noticed any unusual behaviour exhibited by their carefully chosen sticks. Yet some witchers claim

to be able to find septic systems, water pipes, and a host of other buried delights, and know which is which from the witch. Such is the way of magic.

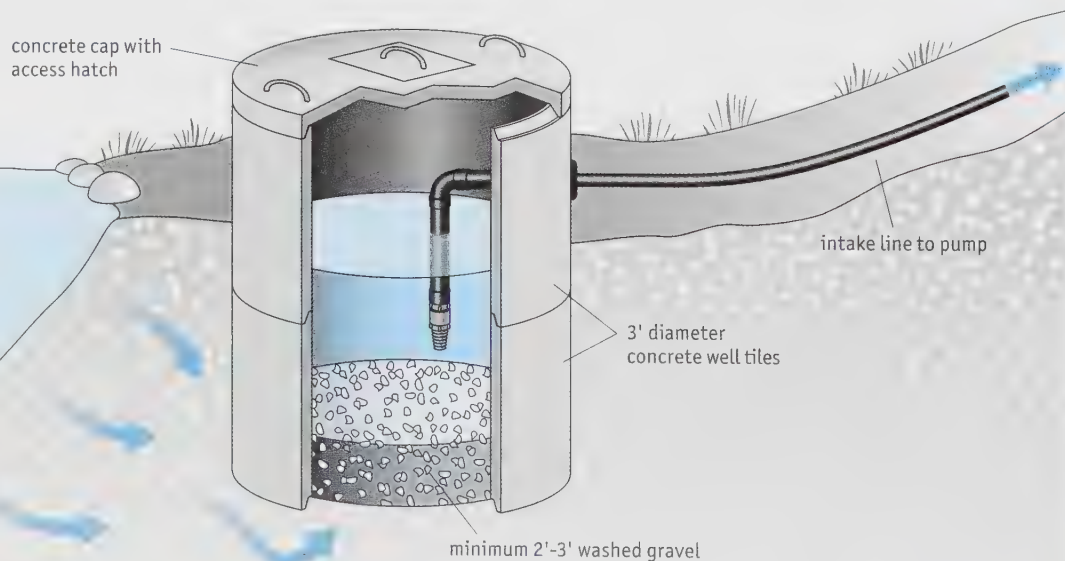
SHORE WELLS (DIY)

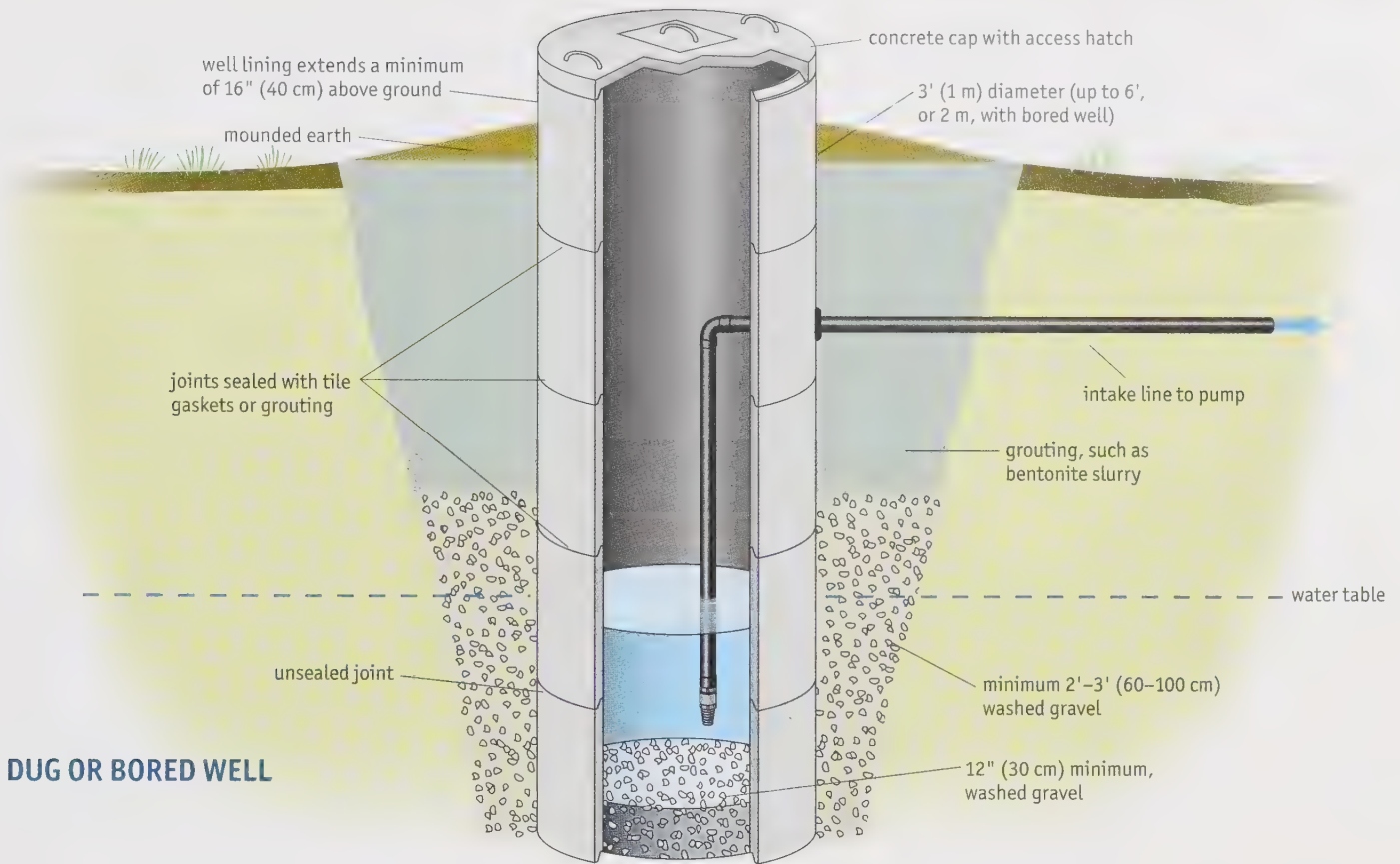
An interesting marriage of surface water and groundwater is the shore well, also known as a dummy well. A dug well (see below) is constructed about 5'–10' (1.5–3 m) back from the edge of a lake, river, or pond. What seeps into the well is primarily, if not all, surface water. Yet because that water must flow through all that soil to get to the well (sand works best), much of the potentially harmful microbes (but not chemicals) are removed through the resultant filtration process, conceivably reducing the degree of treatment required. In common with the dug well, a shore well's intake line can be conveniently buried, thereby eliminating the hassles of intake-line winterization and deterioration (from constant bashing against the shoreline). Shore wells also take a lot of the guesswork out of where to dig for water. As a bonus, because of the well's proximity to open water, it's unlikely to run dry unless the level of the adjacent surface water drops drastically, water levels being about the same for both. As for restrictions, obviously the shore must be suitable for digging, which rules out bedrock,

It's a shore thing:

Blurring the distinction between surface water and groundwater, shore wells (a.k.a. dummy wells) are dug a short way back from a lake river or pond. Yes, most of what they collect is surface water, but because it has traveled through sand or soil on the way to the well, many of the harmful microbes from the surface source get filtered out. Even so, water from shore wells must still be purified before it can be considered potable.

SHORE WELL





DUG OR BORED WELL

and shore wells may not be legal in your jurisdiction. So check with all the various authorities, including any that may regulate alterations to the shoreline, before starting to dig.

DUG WELLS (DIY)

Digging holes in the ground to find aquifers goes back millennia (definitely long before the backhoe was invented). A typical North American dug well is not very deep – about 20'–30' (6–9 m). But it has a large girth, usually 3' (1 m) in diameter, though occasionally up to 6' (2 m). This large diameter allows for more storage, an advantage when a well's yield is low.

It's possible to dig a well using the shovel and blisters method. My grandfather did, and I'm proud of him for it. But strenuous bouts of manual labour are not in keeping with the true spirit of this technological age (at least, that's the rationale I use). And besides, it's an awful lot of work to go through on the off-chance you might hit water. I know of one group of weekend dig-

Digging for treasure:

Dug wells are relatively inexpensive to construct, but they also tend to be shallow – which means they're prone to leaving you short of water during dry spells. Concrete well tiles with sealed joints provide a good-sized reservoir, while a circular concrete cap helps protect the well from contamination.

gers who managed to get 6' (2 m) down before they hit dry bedrock. Digging a well by hand only makes sense if you're in a remote location not accessible by heavy equipment. And you know somebody who can witch.

Lining a dug well

In common with clouds, every well must have a lining – basically a tube that runs between the water and the surrounding earth. The reasons for this are threefold: to prevent the earth from caving back in on the hole; to create a reservoir to gather and hold the water; and to help prevent pollutants from infiltrating that reservoir. Old-timers used stone, but concrete well tiles are now the preferred well-lining material for both dug

wells and bored wells. (They're faster to install and do a much better job of keeping contaminants out of the well.) The 3 ft. (1 m) diameter by about 2.5' (.76 m) high version is almost universal now because, stacked one after another, it provides a good-sized reservoir with enough room for an agile (and younger than me) human to climb down a ladder and service a foot valve if necessary. The tiles stack together, one above the other, cast so that the bottom of the upper tile overlaps the top of the tile beneath it in a loose kind of fit (production tolerances being a little slack).

Although galvanized metal pipe can also be used as well liners, it's best not to as even slightly acidic water can cause the lead in the galvanizing to leach out into the water.

Whatever the material, the well lining should extend a minimum of 16" (40 cm) above the surface of the ground, and all joints within at least 8' (2.5 m) of the surface must be sealed. Dump about 12" (30 cm) of washed gravel into the bottom of the well and 2'–3' (60–90 cm) into the bottom tile's annular space (the space between the outside of the well lining and the dug hole) to restrict the transfer of sand and other fine particles into the well. The annular space above this bottom section should also be sealed to prevent contaminants from seeping through it (see below).

SEALING A WELL

The annular space around any well casing or lining should be at least 4" (10 cm) greater in diameter than the casing or lining, and extend at least 10' (3 m) below the surface. This space is filled with grouting, such as "neat" cement. Neat cement is more sloppy than neat, being the standard 94–lb. (43–kg) bag of Portland cement mixed with 4–6½ US gal. (17–25 L) of water. Other acceptable grouts include concrete, quick-setting cement, and a bentonite clay slurry mixed with water and/or concrete.

With a dug well, the excavated hole is typically much larger than the lining going into it, making it grout greedy compared to bored and drilled wells. And even if laws in your area don't require it, you should still properly seal the annular space around any type of well. It just makes sense.

Bentonite clay boasts two attributes that make it a swell well grout: it readily absorbs water and it swells when wet. So when mixed with water or concrete and placed around a well's lining or casing, it quickly expands to fill in any spaces or gaps.

The shovel vs the backhoe

Whether you're digging with a backhoe or a garden hoe, cave-ins can be a problem in loose, unconsolidated soil such as sand, especially as the hole begins to fill with water. In this respect, hand digging has one advantage over any mechanized means. The problem with doing it by machine is that the entire hole must be dug before installing the well tiles, which means constantly removing earth as the sides cave in. Anyone who has played in beach sand knows this from experience, and also knows that the hole always ends up being much fatter than originally called for – unless we use a pail, which is what we do in a sense when we dig by hand. When the hole is hand dug to about 3' (1 m) deep, the first tile is set in place. (Plenty of friends and a homemade tripod hoist will be required.) Using a short-handled shovel, continue to remove earth from both the well hole itself and from under the perimeter of the tile. The scooped earth is loaded into a bucket, which is then hoisted out of the hole on a rope by a topside helper. Gravity lowers the tiles at a speed directly proportional to how much soil the digger can remove from under the bottom tile, additional tiles being added to the top as the lower tiles slip downward.

The well tiles hold back the earth like a pail set into a hole at the beach, so there's no chance of a cave-in. But, jeez, it's a lot of work, not to mention a mite claustrophobic as you struggle to manoeuvre a shovel and the bulk of one human around in a hole that's 3' (1 m) in diameter and maybe 10' (3 m) or more deep.

Capping a dug well

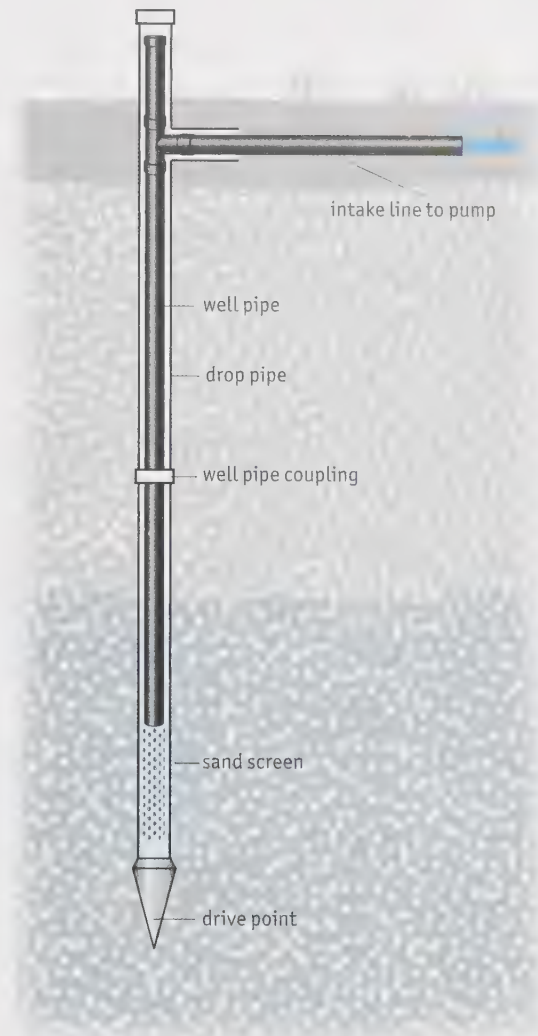
Historically, a dug well remained open at the top so a bucket could be lowered down on a rope to haul up the water. But invariably a bucket wasn't the well's only visitor, as a menagerie of microorganisms, bird droppings, unlucky rodents, dead leaves, and your-guess-is-as-good-as-mine also descended into the well. So any well, regardless of type, must be capped and sealed to prevent all but water and air from entering, the cap vented

and verminproof. Typically, the capping ceremony occurs after the necessary plumbing is installed in the well.

DRIVEN AND JETTED WELLS (DIY)

With driven wells – also referred to as jetted wells or sand points – rather than digging a hole, a narrow pipe – typically 1½"–3" in diameter – is forced into the ground. This is accomplished by either pounding on the pipe's top (hence the term "driven") or by feeding a blast of high-pressure water out the lower end of the pipe, the pipe being fed down as the earth below it is eroded by this powerful jet of water (hence the term "jetted"). In either case, the pipe must be kept vertical, with more sections of pipe added as the well sinks deeper. It's also a good idea to rotate the pipe clockwise from time to time (using an extra-long pipe wrench) to keep all connections snugged up tight. This goes on until the well is about 5'–10' (1.5 m–3 m) into the water table, and then the well is developed using a similar technique to drilled wells (see *Developing a Well*, p. 28). Typically, most of the work is of the manual kind so it's a good thing this type of well is normally quite shallow. Although the pipe's lower end is equipped with a hardened point made from stainless steel, forged steel, or brass, driven and jetted wells are not an option when stone, boulders, or solid-rock formations are encountered. This is a well happiest in sandy soil (hence the term "sand point"). And cave-ins aren't an issue because driven or jetted wells don't remove soil, they simply push it aside.

At the bottom end of the pipe, an intake screen or section of perforated pipe sits just above the point, the point often incorporating a cone-shaped brass strainer. Unfortunately, the pipe's small diameter and short length make for a very modest reservoir, the well relying solely on an aquifer's largesse for uninterrupted supply. Where permitted, it's possible to gang a few driven wells together to increase the total yield (as well as the cost and the labour), but each new hole in the ground increases the risk of contami-



DRIVEN OR JETTED WELL

nating an aquifer, so this is a last-resort scenario. Speaking of which, all driven and jetted wells are difficult to protect from surface water infiltration, the minuscule annular space around the pipe being impossible to properly seal. That said, the surrounding sand will offer at least a modicum of filtration as the water flows through it to the pipe's intake. As with springs, the water should be tested frequently, and treated as required on an ongoing basis.

ECONOMY'S FLIP SIDE

Dug, driven, and jetted wells are all relatively economical to build. Because they are also shallow, all three are susceptible to water shortages during dry periods, though this may not

The no-dig option:

Whether they're pounded into the ground (a driven well) or eased into the earth with a powerful blast of water (a jetted well) these water sources are relatively shallow and cannot be used in rocky areas. They like sandy soils best, which is why they're commonly called "sand points." Because the space around the well pipe is impossible to seal, this type of well is subject to surface water infiltration.

SUGGESTED MINIMUM SETBACKS AND CLEARANCES

(check with local authorities for approval)

Note: Double any setbacks from pollution sources that are located uphill from the well.

Septic system absorption area		
Dug, bored or driven well	150'	(45 m)
Drilled well with watertight casing 20' (6 m) deep	100'	(30 m)
Septic or holding tank	50'	(15 m)
Vault privy	50'	(15 m)
Pit privy or grey water system		
Dug or driven well	100'	(30 m)
Drilled well with watertight casing 20' (6 m) deep	50'	(15 m)
Sewer line (gravity) or building foundation drain	50'	(15 m)
Surface water, including cistern, pool, or hot tub	25'	(7.5 m)
Property line, building, or driveway	10'	(3 m)
Barns, buildings housing animals	50'	(15 m)
Manure storage site, automobile scrap yard, or road-salt storage area	250'	(75 m)
Abandoned wells	200'	(60 m)
Closed-loop ground source heating pipes	75'	(22.5 m)
Sewage lagoons or treatment plants, sanitary landfill sites	1,000'	(300 m)
Hazardous wastes site	1,200'	(360 m)
Cemetery (either human or pets)	50'	(15 m)

ADDITIONAL SETBACKS FOR SPRINGS

Human activity (including habitation) from spring used as drinking water source

downhill from spring	50'	(15 m)
laterally from spring	100'	(30 m)
uphill from spring	200'	(60 m)

be a problem for frugal folks with limited water needs. However, because of the inherent proximity to the surface, contamination of the aquifer, and hence the well, is of greater concern. Such wells are better protected than surface water or springs, but are no match for deep wells when it comes to consistent water quality. The deeper the well, the better the odds its aquifer is, and

will remain, uncontaminated by surface influences. Generally, health authorities consider any well less than 10' (3 m) deep to not be a reliable source of potable water, and therefore in need of treatment before drinking. (See Chapter 6.)

BORED WELLS

While the term “bored well” could describe anyone within earshot of a politician, in this context it refers to a well constructed using what is essentially a mega-sized hole saw. The bored well is a close cousin to the dug well, the choice for well lining material the same, as are the requirements for sealing, capping, and placement of the gravel filter medium. The big difference is that instead of using a backhoe to dig, a boring rig turns a large bucket – picture an upside-down barrel with cutting blades on its leading edge – which is raised and emptied as it fills with earth. What results is a 2'–3½' (0.6–1 m) diameter shaft sunk to a depth of about 50' (15 m) – or twice the average depth for dug well – although 100' (30 m) depths are not out of the question. As the well's near constant diameter is only slightly larger than the well lining going into it, sealing of the annular space is much easier than with dug wells, and usually more successful. Also, a bored well's ample depth and wide girth result in a reservoir measuring in the size XXXL range, making it a good choice where an aquifer might be slow to recharge after use or during dry spells.

As with the much less expensive dug well, the earth must be pliable enough to permit large holes to be poked into its domain (which rules out bedrock) yet stable enough so the hole won't cave in (which rules out sand). Large boulders – which a backhoe digging a dug well might be able to shove out of the way – can stop a boring rig. And so too can topography and nearby structures, for the boring rig is huge, limiting access to sites with plenty of elbow room. It's also the most expensive type of well by far, typically more than twice the cost of a comparable drilled well. For this reason alone, bored wells are losing favour, which means fewer contractors have the equipment to install them, which drives prices

up further, which means fewer people can afford them, which... you get the picture. Not surprising then that most well contractors have forsaken the boring rig for the drilling rig.

DRILLED WELLS

A drilled well is a hole, usually 4"–6" in diameter, drilled into the earth until a suitable aquifer is found. More often than not, this occurs at around 100'–300' (30–90 m), but it could be more than 1,000' (300 m). The use of diamond-tipped drill bits, usually air or water cooled, mean that even solid bedrock, such as the Precambrian Shield, is not immune to being punctured in the quest for water. Although small in diameter, a drilled well can offer reasonable reserve capacity of because of its depth, a 6" casing holding 1.4 US gal./ft or 1.6 L/m.

The well casing, or lining, of a drilled well is usually made of steel, but plastic can also be used (especially if the water is acidic since plastic doesn't corrode as steel does). Below ground and out of sight, the casing should extend a minimum of 20' (6 m) into the hole (the annular space sealed to that depth). Above ground and in your face, the casing should protrude at least another 16" (40 cm), or if situated in a flood plain, higher than the projected flood waters. When drilling into solid rock, the above casing lengths are usually sufficient, as the bore hole in the rock acts as a natural casing down to the aquifer. But there is one notable exception to this rule – when that rock is limestone. Limestone is laced with countless cracks and crevices, interconnecting like city streets twisted by an earthquake (or maybe designed by a traffic consultant). Each crack in the rock becomes a thoroughfare for microorganisms and a variety of surface contaminants, such as septic-tank runoff, pesticides, and petrochemicals. Therefore, any well lining in limestone should extend at least 40' (12 m) into the rock, and the annular space sealed for the entire length of the casing, or to a depth of 50' (15 m), whichever is less.

The casing might also have to extend deeper than the normal minimums if risk of a cave-in is

a concern, such as when drilling through unconsolidated, loose earth.

Steel casings can be welded together, or sealed with a waterproof gasket and then mechanically secured together, such as with an outer sleeve that tightens around the joint. (Anyone who has attempted to put a 5-year-old belt around their waist likely knows how that concept works.) Plastic casing sections are joined with a non-toxic glue. Whatever the material, the casing must be capped with a watertight seal, some jurisdictions insisting that the cap have a lock on it. The cap must also be vented and the vent screened to allow insect-free air in and out as the water level inside fluctuates. Because of its greater storage capacity, a 6" casing is a better choice than the slightly less-expensive 4" variety. When the aquifer resides in sand or loose gravel, a well screen is attached to the bottom of the casing to prevent the fine-grained particles from sneaking into the system and playing havoc with the pump and plumbing (or your cup of tea). The screen is made of perforated stainless steel or some other suitable noncorrosive material, the size of its pores being determined by the size of the particulate that needs to be filtered out.

A pitless adapter connects the well to the intake line. The typical pitless adapter is a sliding, two-piece pipe assembly shaped like a T that, as its name implies, circumvents the need for a well pit (see p. 29). At some point below the frost line (the depth below which the ground usually does not freeze in frigid weather), a hole a tad bigger than the pitless adapter's inlet (2"–4") is made in the well casing, using either a hole saw or a cutting torch. The pitless adapter is installed through the hole from inside the casing, a flange and large lock-nut securing it in place from the outside. In most cases, a rubber-like gasket is sandwiched between the adapter and the well casing, though sometimes the adapter is welded in place. Back inside the well, the sliding part of the adapter slips into the rest of the adapter already secured to, and poking through, the casing. It's this sliding part that holds the drop pipe – the section of pipe running down into the well. (If a submersible pump is installed, it is attached

to the end of this drop pipe, the pump's wiring entering through the well cap.)

An O-ring seal makes the fitting watertight, while allowing for the drop pipe to be lifted out for service. The intake line to the house, cottage, or outbuilding is connected to the adapter on the outside of the well. The hole around the well is then filled with grout.

Because a drilled well usually reaches much deeper aquifers than the other types of wells, it is the least likely to run dry or become polluted.

THE FLOWING WELL

Okay, so all wells are supposed to flow, at least when pumped, but when it pours out the top without your asking, it's called a flowing (or artesian) well. And contrary to the gushers seen in Grade B westerns, this is not necessarily a good thing. A flowing well can lead to erosion around the well and its casing (opening up a path for pollutants to enter the aquifer) and reduce the well's yield. In an attempt to fix the problem, sometimes an overflow pipe is installed. Bad idea, as water and who knows what nasty crud can be drawn back into the well whenever the pump is operated. There are two proven ways to solve the problem: Plug the well if it can't be controlled (an expensive option as a replacement well will have to be drilled or dug) or install an outer oversized casing around the original one, the annular spaces between casings and the outer perimeter both sealed (see *Sealing a Well*, p. 24, for proper grouting methods), the well cap specifically designed to allow venting in a flowing well.

DEVELOPING A WELL

The purpose of developing, or conditioning, a drilled well is to remove any turbidity stirred up by construction, and to ensure that the pores in the well screen (if fitted) or the cracks in the rock through which the aquifer flows are not plugged by ground-up rock or drilling debris. When the well hole sits in soil, pressurized air or water is surged back and forth, dislodging any fine particles, either into the aquifer away from

the screen, or into the well itself. If you've ever used a plunger to unplug a drain or toilet, you're no doubt familiar with the basic principles here. When the hole has penetrated solid rock, a similar but more forceful process known as hydrofracturing is usually the preferred technique. First, a packer is inserted into the well's casing (think of a cork in a wine bottle, with a straw through the cork). Water is then fed through the packer and driven into the cracks and crevices at anywhere from 1,000–5,000 psi, reversing the flow of the well. By varying the pressure, an oscillating action then cleans out and enlarges the openings, encouraging more water to flow into the well. (One caution: On rare occasions, hydrofracturing may open up a subterranean exit for the aquifer, reducing both the aquifer's flow and its reserve.)

Regardless of well type, and whether developed as above or not, all new wells are pumped until the excess turbidity is removed, followed by disinfection (using superchlorination, see Chapter 6) and then tested for potability (see Chapter 5).

REVITALIZING WELLS

Over time, metal corrodes, concrete cracks and degenerates, plastic degrades, and earth and water poke and prod at each other like two kids in the backseat of the family car. Even well standards change as regulatory bodies (generally moving slower than rust and corrosion) attempt to keep up with ever-changing technologies and discoveries. So, got an older well? Unlikely, then, that it's producing like it used to or meeting the current criteria for safe operation. Fortunately, many of the problems a well is apt to suffer can be repaired. Unfortunately, because the job will typically require heavy equipment and expertise, money will also be required.

Assuming the pump and connecting plumbing are all up to snuff, the two most probable causes of decreased well yield are the loss of a well's porosity or the drying up of an aquifer. With the first, you may be able to open up plugged seams; with the second, you either need to go deeper, or bigger, or install a new well.

To unplug dug wells and bored wells, a huge, truck-mounted vacuum similar to what you may have seen dredging out the grunge from city sewers can often suck out the offending debris. This vacuum draws out all the crud and muck that over time can accumulate in the bottom of a well. As a bonus, if the soil is of the correct type (as in suckable, meaning no rock, clay, and the like), it's often possible to insert a plastic extension liner into the well. Measuring just slightly less in diameter than the well's existing liner, the insert is lowered down as muck is removed by the vacuum, thereby increasing the well's reservoir beyond its mucked-in, and possibly original, depth.

If the lining on your dug or bored well doesn't rise at least 16" (40 cm) above ground, or have an approved cap (see above), or the well shows signs of the earth around it caving in, then you might as well hang out the "Welcome Contaminants" sign because they're coming anyway. Or, you could dig away the earth around the lining to about 10' (3 m) down, keeping the hole as narrow as reasonably possible while being careful not to disturb the intake line running out from well. Seal the exit hole around the intake line, then fill the hole with the usual grouting of bentonite slurry or concrete to a depth that will allow you to add a new upper tile that extends at least to the safe minimum of 16" (40 cm) above ground. Seal the joints and top up the grouting to ground level, mound up and slope a bit of soil away from the well, then cap it off with an approved cap.

If the well lining is falling apart but yield is good, rather than abandon the well it may be possible to save it by converting it into a quasi drilled well. Using the standard 6" drilled-well casing with a well screen attached to its end, lower the casing into the well until the screen sits below the water's static level and the top of the casing is at least 16" (40 cm) above finished ground level. Now's a good time to install a well cap on the casing because next you want to do a really weird thing: fill in the rest of the well with clean sand and lop off the remaining well tiles. When sealed and grouted, it's now a faux drilled well.

WE'VE BECOME A PITLESS SOCIETY

A well pit is a recess or hole in the ground, typically about 3' (1 m) in diameter or square, and about the same depth down. The pit bottom is where the top of the drilled well casing terminates. The purpose of the pit was to provide frost-free access to the connection point of well and pipe, and occasionally to also house the pump. Since the arrival of the pitless adapter, well pits are no longer necessary, or legal for most new wells, because of their propensity to pollute the well. Existing well pits can, and should, be eliminated by adding an extension to the top of the casing, installing a pitless adapter, and then filling the pit in with grouting.

Driven wells can be cleaned by extracting the full length of perforated pipe, flushing it free, and then pounding it back in again. Also, of all types, driven wells are the easiest to extend – simply attach another section of pipe to the top and, assuming the soil is soft enough, pound the original pipe in deeper. While going deeper is often possible with other types of wells, it's never easy, and sometimes it can't be done. Also, if using a shallow-well hand pump, jet pump, or piston pump, and going deeper drops the static water level below the 25' (7.6 m) mark, you'll have to replace the shallow-well pump with a deep-well variant. (See Chapter 3.)

For drilled wells, hydrofracturing is often the answer for increasing yield (see p. 28). In fact, the deeper the drilled well, the more likely hydrofracturing will work because the deeper the well, the more cracks and crevices to become plugged and hence, the more available to clear.

As always, disinfect any well immediately after it has been worked on, regardless of well type or nature of the repairs. (See Chapter 6.)

POLLUTED WELLS

Once disinfected, how likely is it that a well will become polluted? A survey of well water quality conducted by the US Environmental Protection Agency found that 37% of the wells tested were contaminated by coliform bacteria (see Chap-

How do wells become polluted? Basically, that hole you poked in the ground can be a two-way street – it not only permits water to flow out, it can also let all sorts of contaminants flow in. For private wells, the main culprit is faulty sewage disposal. In other words, it's possible we're shooting ourselves in the foot. (See Chapter 7, 8, 9, and 10 for a few tips on how to do this.) Other causes include well casings or linings that are insufficient or substandard, allowing surface water into the well; annular spaces not adequately sealed, allowing surface water to seep down the outside of the well lining into the aquifer; and well pits acting as catchment basins for all sorts of nasties, live or dead, natural or human concocted, all queuing up to get into the well. Other popular ways to pollute a well include locating wells too close to pollution sources (abandoned wells being included as one of the sources), or one aquifer polluting another, the two aquifers joined by the well. One well can also pollute a common aquifer serving several wells. Need more? How about surface water seeping into the well around the poorly sealed base of a top-mounted pump and wells being used accidentally or otherwise for the dumping of wastes. And unlike surface water, which is open to change, including for the better, groundwater is very difficult to clean up once polluted.

POLLUTION PRECAUTIONS

Prevention is the key. Maintain your choice of septic system, from outhouse to the latest save-the-planet techno-wizardry. If the well lining or casing is faulty, fix it.

There's no excuse for locating a new well too close to pollution sources. Use the setbacks on page 26 as guides, keeping in mind that they are minimums. Minimum standards yield minimum acceptable results. Increasing them increases the safety factor. Whenever possible, locate wells uphill from any pollution sources, and always slope the surrounding earth away from the well to encourage surface water to drain in that direction.

As for wastes getting dumped into the well, the solution is simple – don't do it. Don't park your

car, boat, or ATV, fertilize the grass, or discard wash water anywhere near the well, don't lean the lawnmower against it to clean the mower's underside, or tie the dog to the well head, or any other too-numerous-to-mention human follies (we're a creative bunch). When planning to do something near the well, ask yourself this question: Do I really want this stuff in my drinking water? When working on or servicing the well, anything you put in there – a new pump, down pipe, or foot valve, whatever – should be disinfected before it goes into the well. It's that simple.

ABANDONED WELLS (DIY)

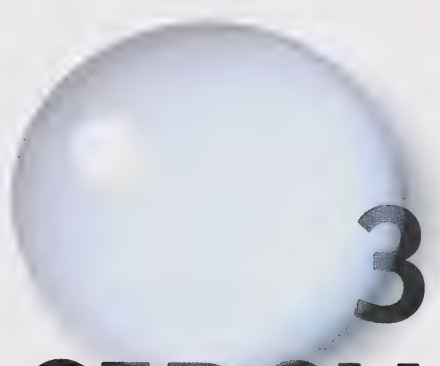
Any well that is no longer in use should be plugged – it's the law in most jurisdictions. Regardless of well type, existing plumbing must be removed, the well then disinfected and pumped out.

For drilled wells, some jurisdictions suggest that the casing be removed if possible, but with or without casing, enough gravel or sand should be poured into the hole in order to cover any sand screen and fractures in rock. This will allow the aquifer to continue to flow uninterrupted as it did prior to having a well poked into it. A wet grouting mixture such as bentonite and cement is then slowly pumped in, filling the hole from the bottom up to within about 10' (3 m) of the ground level.

For both dug and bored wells, the bottom 1' (0.3 m) or so is sealed with bentonite or concrete. After that sets, the well is filled with a mixture of clean sand and a bentonite slurry to within about 10' (3 m) of the ground level.

Regardless of well type, the upper 10' (3 m) of casing or lining is normally removed, the well hole then capped with a 1' (0.3 m) layer of concrete. When the concrete sets, the space above is topped off with clean fill.

There are many variables to the scenarios described above, making proper well destruction a tricky task. If you have any reservations about tackling it yourself, or are not permitted to do so in the jurisdiction where the well is located, call in a licensed well contractor experienced in well destruction.



Pump theory and
pump practice

Manual pumps

Electric pumps

Water-powered
pumps

Pumps for
special places

Features to
look for

3. PUMP & CIRCUMSTANCE

The how and why (and where and when) of water-moving devices



IF YOUR COTTAGE OR HOUSE were downhill from a water source, getting the water inside would be simple: Open the tap (or window) and let gravity do the rest. However, life is never simple. The obvious complicating factor is that such dwellings are rarely downhill from the nearest water (leaks in the roof aside). So to get water from down there to up here, we need a pump.

A pump is just a method of imparting motion to water by mechanical means. As a pump begins to move water, a low-pressure area develops on the intake side of the pump. Meanwhile, atmospheric pressure bears down on the surface of the water source. It's the force of this weight that pushes the water up to the pump.

This illustrates the First Principle of Water System Plumbing: Water cannot be pulled, it can only be pushed. Atmospheric pressure pushes, or lifts, it to the pump; the pump pushes it to its destination, such as your glass, or perhaps a pressure tank (see Chapter 4). No matter how powerful the pump, it can never cause water to

flow to it faster or in greater quantities than atmospheric pressure is able to push it there.

How high can you lift water?

At sea level, atmospheric pressure works out to about 14.7 psi. Because one pound of pressure will push water straight up 2.31' (0.7 m), in theory atmospheric pressure could push a column of water up almost 34' (10.4 m), assuming a completely frictionless vacuum were hovering above it. But there isn't. Due to mechanical and frictional losses, the pump can only manage to lower the pressure, not get rid of it. So the very best we can expect is about 25' (7.5 m) of lift, and that's when the pump is mounted directly over the water source. When the pump is offset from the source – as most systems are – don't count on more than 22' (6.7 m) of vertical lift.

Obviously, few wells sit at sea level. As we move inland to higher ground, the weight of air above us diminishes. The resulting loss of pressure leads to less lift, about 1' (0.3 m) for every

PRIME REAL ESTATE

Pumps perform at their best when located as close as possible to the water source. Obviously, it's tough to beat a submersible pump on that account, but land-based pumps can often be situated almost as near to the source, such as when they're tucked away in a boathouse or a pump house. The object is to take maximum advantage of that meagre potential 14.7 psi of atmospheric pressure. Up close and personal reduces suction-head loss (a.k.a lift loss), the water arriving at the pump closer to the initial atmospheric pressure that began pushing it there. This results in faster start-ups and less wear on the pump and, as the pump then adds to that pressure, the water arrives at its final destination with more tub-filling power.

Aside from improving pump efficiency, relocation can also move the noise away from living areas. A pump house should be weatherproof, adequately vented and, if winter use is planned, fully insulated. (See Chapter 11 for more on keeping a pump house toasty.) As a bonus, insulation also helps to subdue pump noise.

The structure should be above the flood plain (if possible) and the high-water mark if parked near surface water. If pack ice is apt to overflow the shoreline in the spring, set the pump house back far enough to escape damage. It's also nice to have enough room inside to move around and service the pump.

Regardless of locale, pumps should always be securely anchored in place. A bouncing or moving pump puts a strain on the plumbing connected to it, which is a bit like putting the welcome mat out for leaks.

1,000' (300 m) increase in altitude. So a cabin located in the Beartooth Range, Wyoming, 8,000' (900 m) above sea level (just a rockslide east of Yellowstone National Park), would have an approximate maximum lift of about 14' (4.3 m) for an offset pump.

While the atmosphere can only flex 14.7 psi worth of pressure at best to push water around, even a basic centrifugal pump can muster as much as 150 psi at the push of a button. So let the pump do as much of the work as possible. The easiest way to do this is to locate the pump as close to the water source as you can. (See Prime Real Estate, above).

Which brings us to the Second Principle of Water System Plumbing: No system achieves 100% efficiency, mainly because of head loss, which is the friction generated between moving water and the surrounding pipe wall. This loss varies with temperature, pipe size, pipe ma-

terial, types of fittings (such as elbows and inline valves), volume of water being transported through the pipe, and pipe length. Head loss increases as distance, volume, and the number of fittings become greater. It applies to both lift and discharge heads (see Talking Heads, p. 33), and horizontal runs, head loss reducing the theoretical potential of all three. Lift loss and head loss determine the maximum allowable offset for terrestrial pumps.

If it weren't for head loss, a pump operating at 50 psi could push water 115' (35 m) straight up and move water horizontally forever. You can often compensate for head loss, at least in part, by increasing pipe diameter. But installing oversized pipe can overwork the pump, too. Pipe should always be of the correct diameter for the distance covered and the size of pump and pressure tank involved. If you're into formulas and calculations, pump manufacturers have all sorts of them to play with, allowing you to determine the exact pump, pipe size, and pressure tank required for your needs. Or you could simply ask your local plumbing-supply shop.

Besides knowing the lift and discharge head of your site, another helpful measure of performance is a pump's capacity to move water – its flow rate – rated in US gallons per minute (US gpm) or litres per minute (L/min). The pump must be able to handle peak demands, like those busy hours around breakfast and early evening when showers are run and dishes are washed. Most of us can get by with a pump capacity of about 5 US gpm (20 L/min), those without showers and such requiring even less. But if you've got a thirsty dwelling, with multiple washrooms, a dishwasher, hot tub, (and maybe a few teenagers), do the calculations or talk to a reputable plumbing store or plumber.

Some jurisdictions have stringent rules governing pumps and their installation (such as Wisconsin where only licensed installers are permitted to put in a pump), while other jurisdictions don't seem to care who the heck does it or how (Ontario law allows homeowners to do the work). Check with your local authorities before they check with you.

THE PUMP PORTFOLIO

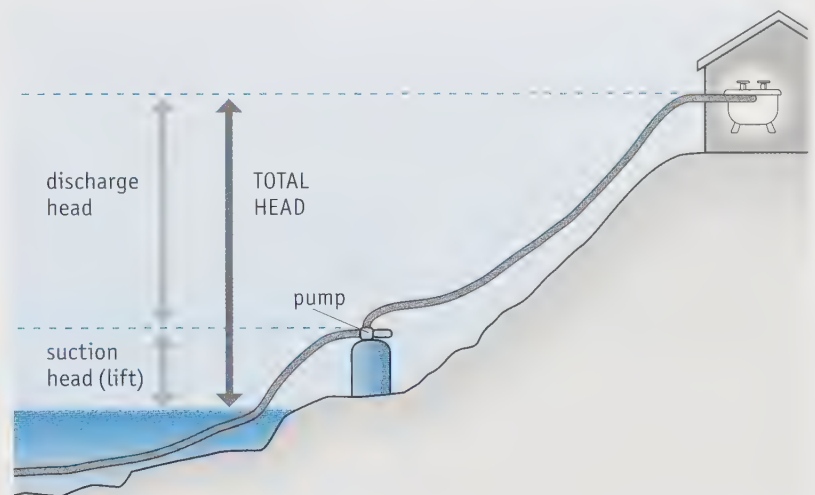
The categorization of pumps is not a tidy process, with some overlap inevitable no matter how we divide things up. That said, I have squeezed the pumps most likely to be conscripted for house or cottage duty into one of two very broad categories: positive displacement pumps and centrifugal pumps. But be forewarned: It's possible your friendly (or not) neighbourhood supplier won't have a clue what you're talking about should you ask for a pump by either of those categories, so finish reading this chapter for more detailed descriptions before you go shopping. And a note regarding total head (the average, approximate, or expected lift and discharge head): Your mileage may vary, pumping capacities being somewhat site and circumstance specific.

POSITIVE DISPLACEMENT PUMPS

A positive displacement pump draws one batch of water into the pump at a time, displacing existing water inside the pump with incoming water, the water being pushed out in small batches rather than in a continuous flow. A positive displacement pump usually doesn't require a foot valve (see p.57) to keep the water from running out the bottom of the intake line or a check valve to keep the water from running out the bottom of the pump (though the addition of a foot valve will often improve efficiency and start-up time). And it won't lose prime should a little air get into the system.

Most non-electric pumps are positive displacement pumps. Most are also of simple design, which typically translates into reliability. Most are hand-operated, though some are foot-operated, some wind-powered and, believe it or not, some are even bicycle powered. Whatever the method of operation, the common element is that the electric company doesn't have its hand out every time you want a glass of water. So these are the pumps of choice for many who lack

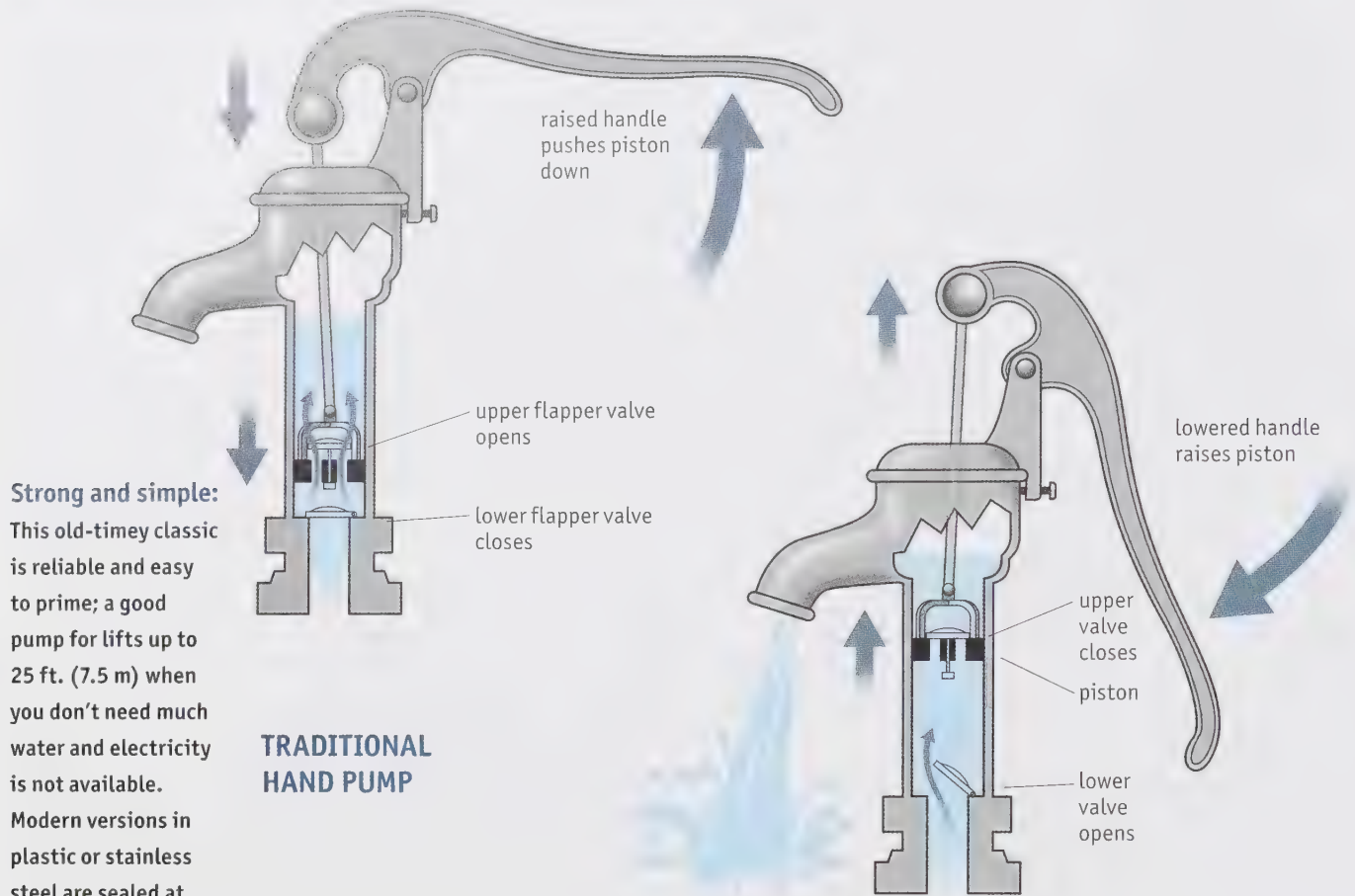
electricity (or who are exceedingly cheap). Usually, such pumps come up wanting when asked to supply sufficient pressure to operate all the plumbing luxuries that have evolved into necessities, such as automatic dishwashers and showers (but not always, exceptions noted below). That said, if electricity is not available to operate the pump, chances are it's not there for those modern conveniences either. However, most positive displacement pumps can produce sufficient pressure to fill a household pressure tank, which means running water to every tap, toilet, and fixture (assuming it's possible to find an agreeable arm to pump the water into the tank as needed). Even if they're willing to forsake modern conveniences for the simpler life, anyone considering such a pump should be reminded that the manual pump is manually powered. The force



TALKING HEADS

The vertical distance from the water source at its lowest point of the intake line up to the inlet of the pump is known as lift head or suction head. The distance from the pump to its point of delivery is the discharge head. Generally, the less lift head or suction head, the greater the potential discharge head. The sum of the two is known as the total head, or total lift. As total lift increases, the discharge volume and pressure (key contributors to a good shower) decrease and the effort required to pump increases.

The level water normally rests at when just sitting around in a lake or well is known as the static level. The amount that level drops in a well in a specific period of time is known as the drawdown.



Strong and simple:

This old-timey classic is reliable and easy to prime; a good pump for lifts up to 25 ft. (7.5 m) when you don't need much water and electricity is not available.

Modern versions in plastic or stainless steel are sealed at the top to prevent contamination.

Deep-well versions are available.

TRADITIONAL HAND PUMP

required on the handle increases in direct proportion to the depth from which the water must be drawn. Potential discharge is dependent on both the force exerted on the lever and the frequency of the pumping action. More work equals more water.

Traditional hand pumps: the low-tech option

Perhaps the most widely seen variation of positive displacement pump is the traditional hand pump (or cistern pump, as it is also known). It's also a bit of history – one of the few non-fire-arm props seen in better western movies that is still made today. The handle of the pump is connected via a rod to a piston that moves up and down inside the cylindrical pump body. Traditionally, a circular piece of leather attached to the piston made a sliding seal between the piston and the cylinder, but today the seal is more likely to be made from some wonder synthetic. When

the handle is pushed down, the piston is raised, creating a low-pressure area behind it within the cylinder. This lifts a flapper valve (a small hinged lid not unlike a toilet seat cover in concept) at the bottom of the cylinder, allowing water to flow into the cylinder. As the handle is raised, typically producing a loud squawking sound, the piston is forced back down and the lower flapper valve falls shut, the pressure of the squished water forcing a second flapper on the top of the piston open. The water flows through this second flapper valve past the piston, but remains in the cylinder.

Astute readers will note that we're now back where we started – almost. The big difference is that the next time we push the handle down, as the piston rises (the upper flapper held in closed position by the water above), the water now on top of the piston is pushed out the pump spout in a sudden whoosh as a new batch of water is drawn in below. This cycle is repeated for as long

as the handle is pumped. (Attach a campaigning politician's right hand to the pump handle and you'll have a constant supply of water, at least until the election is over.)

Usually, a cup or two of water poured in the top of the pump is all the priming it needs as long as the lower flapper valve remains wet and supple enough to seal efficiently. This valve will eventually let the water inside sneak past, drying the flapper enough to require re-priming of the pump. How long it takes for this to happen depends on the make and condition of the pump, but it might go on working trouble-free for years. Flapper valves and piston seals can wear over time (usually from long periods of remaining dry), so leave a few bucks in the will for your grandchildren to replace them.

Only a few manufacturers are still making this type of pump, and fewer still make the traditional as-seen-in-westerns variety, a reflection of their declining popularity (which in turn increases prices). The better of newer variations are made from stainless steel (such as the Simple Pump), or plastic (such as the Oasis), and are sealed at the top to prevent outside contamination.

Non-freeze versions relocate the piston and cylinder deeper into the well via a longer connecting rod and intake pipe, that pipe having a wee hole drilled into it at the bottom to let the water drain out of the pump between uses. (This diminutive hole can clog with debris and water-borne minerals, requiring periodic checking and cleaning out.) Deep-well applications use a similar system, only with a much longer connecting rod and intake pipe. With either system, atmospheric pressure only has to push the water into the submerged end of the pump, the piston pushing the water up from there. But each will tax the pumper more, the effort increasing in direct proportion to the depth of the cylinder and piston. And the deep-well version can cost at least twice that of a standard hand pump.

My in-laws had a traditional cast-iron hand pump drawing from the well at their first cottage. The pump fed a 12 US-gal. (45-L) tank sitting atop a water tower. The tank was set at roof

height, thus providing pressure for the kitchen tap and a low-volume-flush indoor loo. The system worked surprisingly well, the only thing missing being a blow-me-down high-pressure shower. But it's still possible to have your hand pump and shower too. Some newer hand-operated pumps will connect directly to your water system (where not prohibited by law), allowing a keen and healthy pumper to fill a standard pressure tank. Voilà, enough pressure for a shower. Some of the newer variations will also connect in parallel to an electrically operated pump, such as a jet pump or submersible (see pp. 41 and 43), ready to supply the house system with water in the event of a power failure, a feature not as steeped in history as its basic design.

Total head: Standard versions will lift water up from depths as deep as 22' (6.7 m), while deep-well variants typically draw from about 50'–300' (15–90 m), though some will work in much deeper wells – check with the manufacturer. Discharge head is dependent on pump design and the amount of effort the pump operator can be coaxed into providing, but 20' (6 m) is usually not too taxing.

The hand diaphragm pump: The no-prime priming pump

Instead of using a piston in a cylinder combo as above, the hand-operated diaphragm pump takes advantage of the flexible nature of a thin rubber-like membrane – the diaphragm. When raised, the handle of the pump lifts the diaphragm, increasing the volume of the pumping chamber to establish the required low-pressure area. This in turn pulls open a small flapper valve on the intake side while pulling another shut against the pump body on the delivery side (much like the traditional hand pump's flappers, only smaller). When the handle is lowered, the downward thrust of the diaphragm pushes the intake valve shut while forcing the pump's contents out the discharge flapper. The pump works in or out of water, and will pump air or water, which means no priming required, thank you very much – a true self-primer and a swell rural or cottage accessory.

JUST ADD WATER AND STIR

A self-priming pump is one that can draw water up an empty suction line. Most so-called self-priming units – the traditional hand pump, for instance – can only do this following an initial prime, and for such a pump to remain self-priming, some water must remain in the pump housing (the quantity depends on the design of the pump). So when brochures or folks in the business talk about self-priming, what they usually mean is self-repriming. Pumps that are truly self-priming (like a diaphragm pump, for example), meaning that they can draw in water without any initial prime, will be referred to in this book as true self-priming.

Equal time for personal prejudices department

Yes, there are other brands of hand-operated diaphragm pumps on the market, but I really like the Guzzler. Although we used the base-model Guzzler to supply our cottage for several months while we were between pumps (recreational activities taking precedence over work), this pump's main purpose in life is to assist in the priming of jet and piston pumps (see Chapter 12). But it will also pump out a sailboat after the big storm (or dunking), supply water during power outages, replace a traditional hand pump, fill a cistern or water tower or, with a simple nozzle attachment, shoot water over 30' (9 m) horizontally or 16' (5 m) straight up, making it a dandy device for emergency fire fighting or dousing the neighbour's noisy kids and their portable stereo. You can even hook it up at the pump end of the system and push the water out of a line for winter storage. All this and more without using a watt of electricity.

The base-model, plastic-bodied Guzzler is small and lightweight (1¼ lbs. or 550 g), and sells for less than a hundred bucks.

Total head: The base model's practical lift and discharge head are both given as 13' (4 m), the effort to pump increasing considerably be-

yond that. That said, I have used the base-model Guzzler to lift water up from a depth of about 22' (6.7 m) over a horizontal distance of about 200' (60 m), two people pulling on the handle as the water neared its destination. Regardless of brand, potential quantities are dependent on both the capacity of the pump and how quickly you work its handle.

ROTARY PUMPS: THE WATER GOES AROUND AND COMES OUT HERE

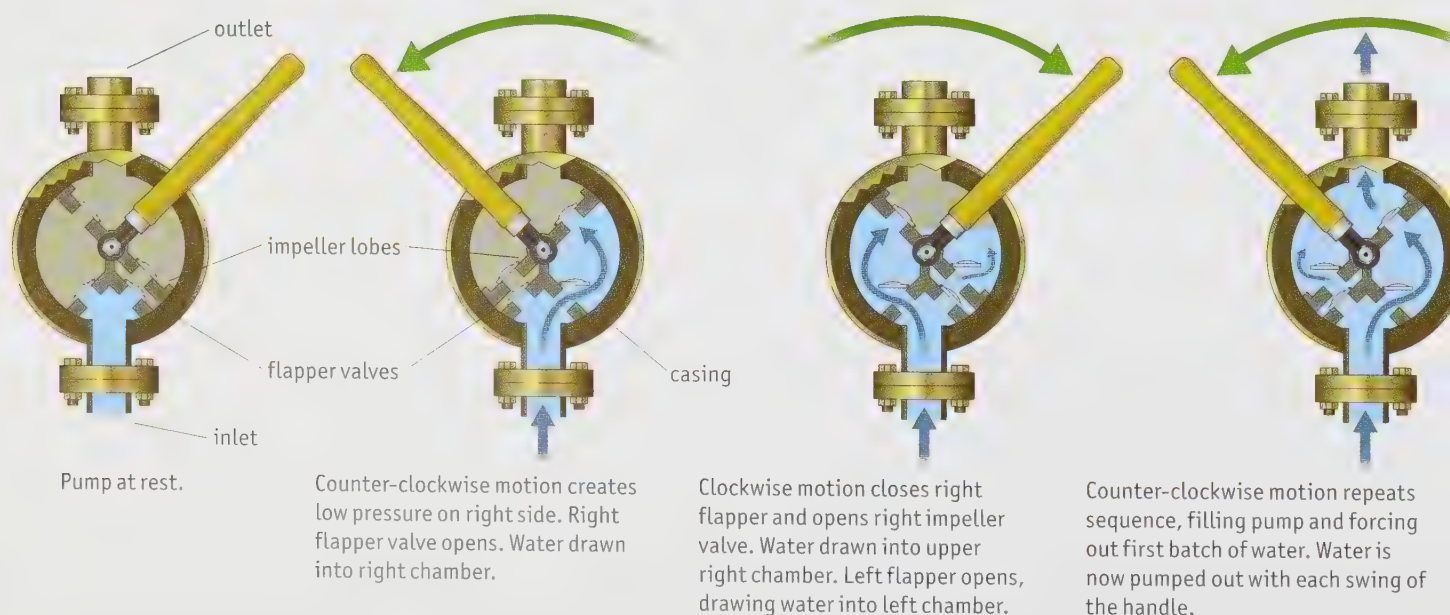
Rotary pumps work by spinning an impeller (or impellers) around inside an enclosed housing, the blades of the impeller moving the water. That impeller can be a gear with wide gaps between its teeth, or a series of lobes attached to a central shaft. The most prevalent version is the gear pump, but should this variation turn up at the house or cottage, most likely it will be serving as an oil pump in some piece of machinery rather than the water system, so that's enough said about that.

A member of the rotary club better suited to supply water is the double-acting semi-rotary hand-operated wing pump, such as the Sigma K2. Picture a cookie tin about 6.5" (16.5 cm)

The power of push and pull:

A wing pump is a high-performance hand pump, with lifts up to 22 ft. (6.7 m) and discharge heads up to 82 ft. (25 m). This true self-primer can be used on its own or as a back-up system, able to fill a standard pressure tank with no electricity. Can be connected in parallel to regular water system.

DOUBLE-ACTING SEMI-ROTARY WING PUMP



round by 2" (5 cm) high (okay, so they're small cookies). Now add a 15" (38 cm) long handle attached to the circle's centre. When this handle is pushed and pulled back and forth through a 110° arc, it turns a shaft inside with four attached lobes (or wings), the lobes brushing the inside edge of the cookie container (officially known as the pump casing). The space between each lobe acts as a separate chamber. When the handle is pulled, half the lobes pass by the pump's inlet, creating a low pressure area in the corresponding empty chamber, causing the inlet flapper valve to open and let water in. When the handle reaches the end of its swing and begins its pushed return, the inlet flapper closes and the lobed chambers deliver their batches of water to the outlet port of the pump. Meanwhile, the other lobes and chambers are doing the opposite thing, meaning that water is constantly being pumped in tiny batches.

This pump must be vertically bolted in place. As with all hand-operated pumps, in addition to being a sole water provider, the Sigma can also serve as a backup system should the power, or main pump, fail. According to its manufacturer, the Sigma can leap tall pipes in a single bound to fill a standard pressure tank for handy tap delivery of water. Connected in parallel to the existing water system, it's purported to be able to draw water from the source through an existing pump, even a submersible, though I haven't tested this claim.

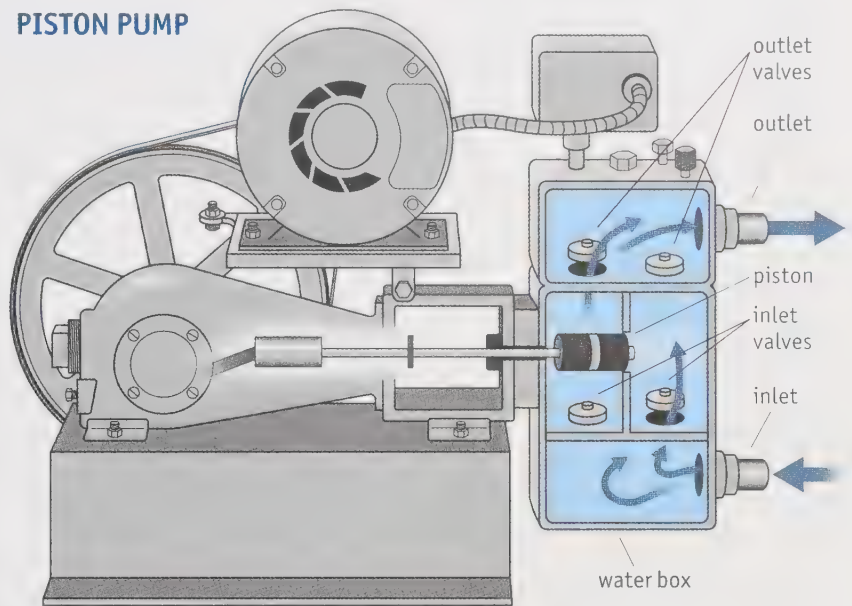
Total head: Good for lifts up to 22' (6.7 m), and discharge heads up to 82' (25 m).

PISTON PUMPS: FOR THE INCURABLE TINKERER

The piston pump (also known in some circles as the reciprocating pump) is essentially a motorized version of the traditional hand pump, at least from the standpoint of how the water is drawn in. It's simple to prime – remove the prime plug (located on top of the water box), fill the water box with water, and start the pump. When the water pours out the plug hole, stop the

pump and replace the plug. Then turn the pump back on and if it works, you're done. If not, repeat the procedure. However, Max's Amazing Easy Prime is a more expedient and surefire method of priming, and it works with all types of powered pumps (with the exception of the submersible pump, which is self-priming). See Chapter 12 for details.

PISTON PUMP



Belt-driven beauty:

Becoming a bit of a rarity these days, piston pumps are complex, relatively expensive, and require regular TLC. That said, they're easy to prime, tolerant of small quantities of air, and make a great sound. A good choice for low-yield wells and high discharge heads. Lifts up to 25 ft. (7.5 m).

Unlike the ubiquitous jet pump (see p. 41), a positive displacement pump, such as the piston pump, does not depend on the speed of water to build pressure, so any decrease in discharge head is restricted to frictional losses only. This advantage is only realized when high discharge heads are encountered and the water just keeps flowing. Or pulsating, actually, the water being delivered in tiny rapid-fire batches.

The piston pump is complex and becoming a bit of a rarity, making it more costly than the more-popular jet pump. Today, piston pumps are used mainly to move everything but water, primarily in industrial and agricultural situations, but a few manufacturers are still making

water pump versions, though it's unlikely your local plumbing supply store will keep them in stock. Pity, because it's a glorious thing to watch in action, with crankshaft, connecting rod, piston and valves softly chug-chug-chugging away – a pump for the incurable tinkerer. There are oil levels and belt tension to check, oil to change, and, if you're really lucky, you might even have to repack the stuffing boxes. Those keen on such things will be rewarded with a reliable pump. Those who lack an interest in preventative tinkering will be better served by a jet pump.

Inside the piston pump, the flow of water is controlled by valve rubbers which perform the same function as the hand pump's flapper valves. Instead of displacing a single cylinder of water as the hand pump does, this pump's piston fills and empties two chambers as it reciprocates through each cycle. Like other pumps in this category, it requires neither a foot valve nor a check valve (though it will reprime more readily with a foot valve); the twin lower valve rubbers stop water from draining out of the water box. The water box must be full of water for the valve rubbers to work, but after its initial prime, the pump can tolerate a fair amount of air without losing prime. This makes it a good choice for low-yield wells (like sand points) and springs, though fine sand can wear out the valves and seals over time.

To protect inquisitive fingers, a piston pump should be installed with the pulleys against a wall or equipped with a belt guard. If the motor on a piston pump should ever fail, one can be salvaged from a cast-off washing machine or similar device, a luxury not shared with other pumps. This flexibility allows for the installation of a more powerful motor to increase pump capacity, as long as the pump and electrical circuitry are up to handling the increased loads.

Piston pumps consume less electricity than comparable centrifugal pumps at start-up, and are therefore better suited to drawing power from a portable generator, a potential advantage for remote sites.

Total head: Good for lifts up to 25' (7.5 m), and discharge heads up to 200' (60 m), depending on model.

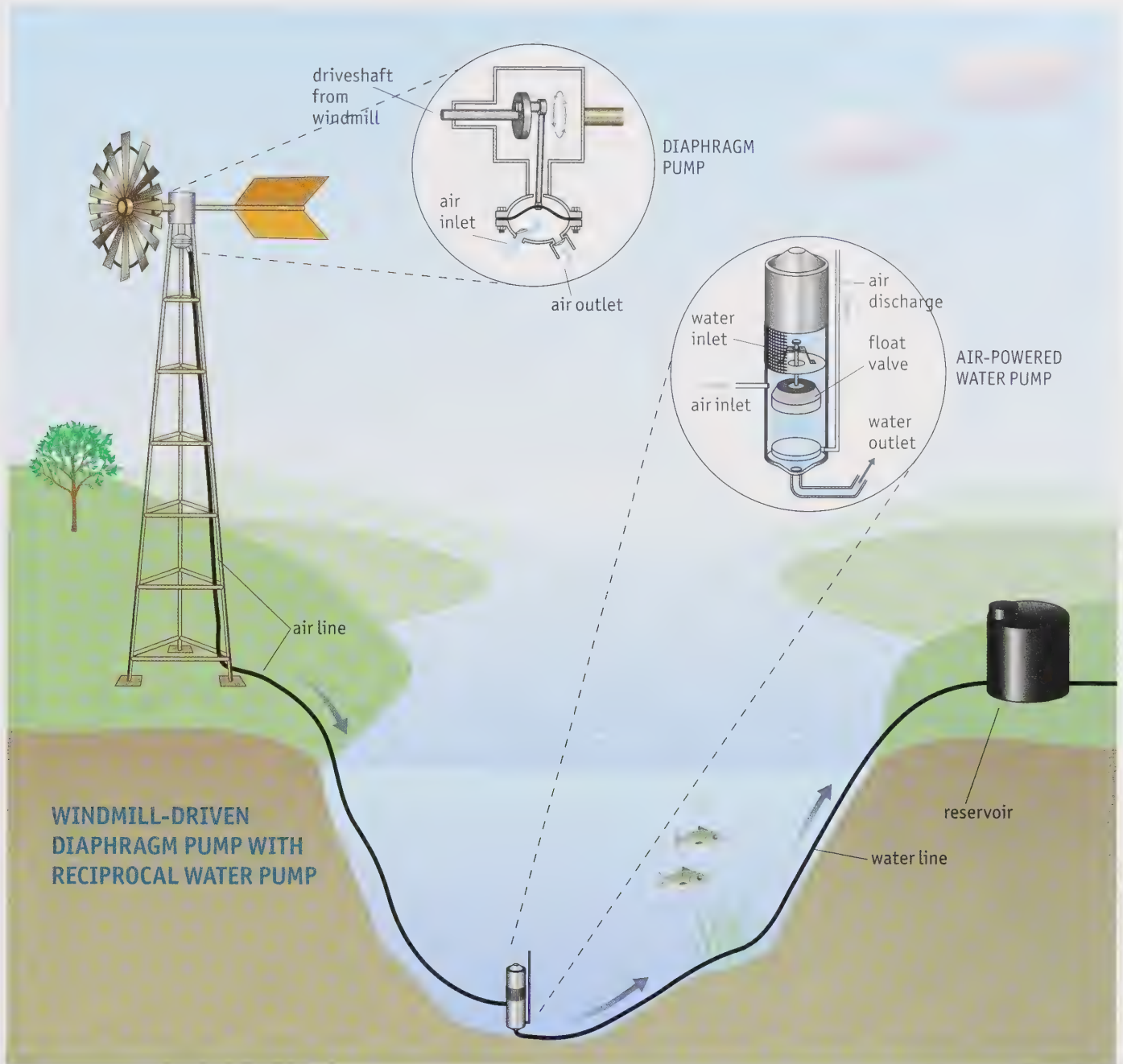
WIND-DRIVEN PUMPS: BLOWIN' IN THE WIND

One pumping system that I have yet to own but dearly long for, having been captivated by it since childhood (which works out to way too many years), is the windmill. Admittedly, the main motivator is romance, though once past the fright of initial cost, you can justify the choice by its negligible operating expenses. But who needs to justify the tranquil beauty and gentle flutter of a windmill's blades spinning slothfully through a gentle breeze as they toss the glow of a setting sun all over the yard?

While it can be argued that the windmill is an impractical mechanism when it comes to the production of electricity, for those without electricity, a wind-powered water pump can make sense. Mostly, it relates to storage. Electricity is difficult and expensive to store; water is easy and economical to store.

Even in a stiff breeze, don't expect a windmill to deliver water like an electrically powered pump. Traditional windmill pumps are positive-displacement pumps, basically hand pumps powered by wind, with delivery to match. With tower, blades, pump and all related goodies suitable for a drilled well, a traditional windmill will cost about ten times what a submersible would set you back. And it must be mounted directly above the water source, limiting it to well applications. Such a unit will deliver about 1.7 US gpm (6.5 L/min) in a 12 mph (20 km/h) breeze. If the breeze holds, you can expect 100 US gal. (400 L) in an hour. At 3 mph (5 km/h), you'll get 1–2 US gal. (4–8 L) an hour. At wind speeds below that, most windmill pumps won't start. For both safety and functional reasons, the windmill blades should be about 16' (5 m) above any objects within 400' (125 m) of the tower.

For those not bent on tradition, there is a more modern and less-expensive alternative. This wind-driven pump pushes air into a reciprocal water pump – a submerged tubular chamber with a float valve towards the top. When water enters the chamber, the float valve rises, closing off the intake. As the pump continues to push



Two elements, one goal. How to move water with wind power:

Ideal for low-yield situations, windmill-driven diaphragm pumps are slow and steady, best-suited for filling reservoirs. True self-primers, they are not affected by dry operation (such as when the water source dries up). Very expensive but operating costs are almost non-existent. Good for lifts of 50–300 ft. (15–90 m), depending on wind strength and pump configuration.

air through a long hose down into the chamber, the water is forced out and up the intake line to its destination, typically a storage system of some sort. When the water level in the chamber drops a predetermined amount, another valve releases the air (and therefore pressure) out of the cham-

ber, and the upper float valve drops, letting another bunch of water in. The water in the tube rises again, forcing the float valve shut, and the process starts all over again. This type of windmill is suitable for dug wells and surface-water applications (the windmill in the latter case be-

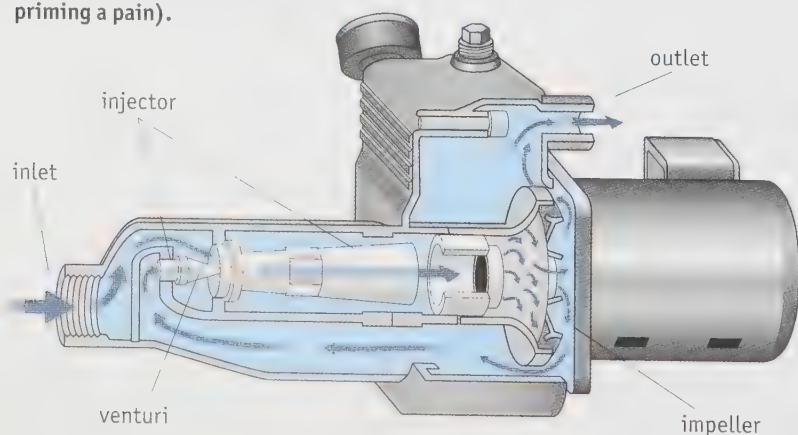
ing located on land adjacent to the water, rather than directly above the water, such as it would with a well). Originally designed to fill watering troughs for farm animals, it will run in extremely light winds (2–3 mph or 3–4 km/h), delivering just a shade less water than the above-mentioned traditional windmill. And it aerates the water source, contributing to the health of the water. (See *Nutrients*, Chapter 5.) All this and the romance of spinning blades for only twice the cost of a submersible pump.

Both types of windmills are true self-priming pumps, and are unaffected by dry operation. You can leave either to operate on its own, filling the reservoir as long as there's water to pump, and should the well, pond, or lake run dry, the blades just keep spinning around aimlessly with no harm done, entertaining you while waiting for the well to replenish itself. Ideal for low-yield situations.

As with the hand pump, windmills are not for serious consumers of water. The size of the reservoir required must take into consideration the family's needs, peak demands, average wind speeds for your area, and windless days. And, just in case the wind doesn't cooperate at all, it's a good idea to have a back-up pumping system or rainwater collection system.

Total head: Depending on wind strength, size and pitch of the blades, and the pump, a windmill can lift water up to 300' (90 m), but is generally much happier with lifts of 50' (15 m) or less.

SHALLOW-WELL JET PUMP



CENTRIFUGAL PUMPS: HIGH-VOLUME DELIVERY

Unlike the pumps discussed so far, a centrifugal pump delivers water in a smooth, steady stream, compliments of its impeller. (An impeller moves water, as opposed to a propeller which moves the object to which it is attached – such as a boat – through water.) When the impeller begins spinning within its housing (or casing), the flow of incoming water accelerates. As the speed of any liquid increases, its pressure drops, creating a low-pressure area behind it. At the same time, the spinning impeller discharges the accelerating water into either a volute (similar in shape to the shell of a snail) or a diffuser (a compacted version of the volute), both of which slow the flow as it progresses through an ever-widening passageway. As the speed of the moving liquid decreases, its pressure increases. In the confines of a pump, where frictional losses are minimal, the resultant pressure is what we count on to deliver the water to the kitchen tap. Daniel Bernoulli, king of the fluid frontier, discovered this relationship between velocity and water pressure more than 300 years ago.

The capacity of a centrifugal pump is controlled by a balanced partnership of motor, impeller, and volute (or diffuser). A manufacturer must match all three to work together, as a centrifugal pump functions best when it's operating at full capacity, that capacity closely related to discharge head; the greater the head, the less capacity. And it's just as particular on the intake side of things, not being keen on variations in either the pressure or the volume of the incoming water. It's also intolerant of air and any break in the water around the impeller, including simple air bubbles, can lead to loss of prime.

Most permutations of the basic centrifugal pump intended for home use are self-priming after the initial prime, as long as water remains in the pump casing and intake line. A foot valve, or a check valve just before the pump, is a must (see Chapter 4). The pump is simple, inexpensive for a motor-driven pump, not as noisy as the piston pump, reliable, and low on maintenance – not a

The people's choice:

Not just for wells, shallow-well jet pumps are great for surface water, too. That's why these pumps are the old standby in cottage country when lifts do not exceed 25 ft. (7.5 m). Simple and reliable, these inexpensive jets provide good volume, but are intolerant of air in system (which can make priming a pain).

good pump for avid tinkerers. Because basic centrifugal pumps are best suited to moving water in high volumes, rather than at high pressure, they're commonly used as portable gas-powered pumps (used either to fill reservoirs or fight fires) or as sewage pumps. (See Chapter 7.) However, there are variations of the centrifugal pump designed specifically for filling the needs of the home or cottage water system.

JET PUMPS: CENTRIFUGAL PUMPS WITH A BONUS

The jet pump is a type of centrifugal pump with an important bonus – an injector (sometimes referred to as an ejector). The injector sits in the path of the incoming water. As water is drawn into the pump by the action of the impeller, a portion of the water that might otherwise be destined for some plumbing fixture is recirculated back through the injector. Inside the injector is a venturi (a narrow tube through which the water is forced). Much as a river picks up speed as its banks converge, any water passing through the injector will also accelerate. It's this sudden increase in speed that establishes the low-pressure area required for atmospheric pressure to push the source water up to the injector. This incoming source water joins the fast-flowing, pressurized recirculating water to squeeze through the venturi. The speed of the water then slows as it flows out through an ever-widening cone-shaped passage. As velocity diminishes, pressure increases, much in the same manner as when water leaves the fast flow around the impeller for the diffuser (which also explains why many manufacturers refer to the entire venturi tube as a diffuser).

Jacuzzi lays claim to being the first pump manufacturer to implement this clever application of Bernoulli's observations. Obviously, Dan (as Bernoulli's friends called him) must have owned a really cantankerous pump to have figured out all this stuff about the flow of liquids. In essence, what the jet pump is doing is exchanging a portion of potential output (in the form of

energy lost in recirculating the water through the injector) for an additional boost in pressure on the lift side of the impeller. How does this improve pumping? It depends on the location of the injector.

Shallow-well jet pumps: Not just for wells

Like the piston pump, a shallow-well jet pump (typically referred to simply as a jet pump) is designed to lift water up to the house or cottage from any source that is less than 25' (7.5 m) below the pump, such as a shallow well (surprise) or a lake. It is the most common pump for private residences, though the submersible pump (see p. 43) is certainly challenging that title.

PREVENTION IS WORTH A POUND OF BURNED-OUT PUMPS

Goulds Pumps Incorporated have a neat solution to the problem of lost prime on its J and G series jet pumps; a diaphragm that divides the water box. The diaphragm is a stiff piece of rubber-like material with two quarter-sized holes towards the top. The water enters the impeller side of the diaphragm through the injector, and exits back into the discharge side through the two upper holes. As only the water above those holes is being pumped out, if we're not bringing any additional water in, the water won't rise above that level. It's a bit like the overflow drain on the bathtub – the water pours in, spilling out the overflow when it rises to that level. Water always remains in the tub until somebody pulls the plug. What does this mean to us?

The company claims that if the pump loses its prime – from a leaky foot valve or hole in the intake line, for instance – the diaphragm keeps the impeller and the seal in water. The only way to rid the water box entirely of water is to remove the drain plugs. Just like a tub. The impeller just splashes around in its own bath, staying lubricated and cool for up to 36 hours, at least according to the admittedly biased manufacturer. Personally, I don't have the resources to sit around waiting for a pump to burn up just to see how long it takes. However, what I have witnessed is how well the Goulds pump will self-reprime after an intake line failure, without having to add any water, and that is neat. Company representatives even boast that a system having a 1" intake line, a 15' (4.5 m) vertical lift, and 100' (30 m) of offset between the water source and pump, will start pumping water in about four minutes after filling the impeller casing with about 1 US qt. (1 L) of water.

The shallow-well jet pump has its injector built right into (or attached directly to) the pump casing immediately before the impeller. The injector acts like a supercharger, increasing the pressure of the water being fed to the impeller, which in turn increases it again.

The jet pump is relatively inexpensive, a simple variation of the basic centrifugal design, and if working within its design limitations, delivers a good supply of water. Most jet pumps will quickly lose prime if air gets into the line, so they are not the best choice for low-yield wells like sand points. Loss of prime can also result from such perennial favourites as leaks in the suction line, or foot-valve failure – but whatever the cause, the pump's impeller will soon be spinning in air. And this is not just a problem for any unfortunates caught in the shower. In common with any land-based centrifugal pump, the mechanical seal where the impeller shaft enters the pump casing will quickly burn out without water to lubricate and cool it.

Sand, gravel, and sediment can block the injector, and wear the impeller, diffuser, and mechanical seal. Aside from those potential wear points, as long as the impeller casing doesn't run dry, the jet pump tends to be more reliable than the piston pump, and about as maintenance free as any non-submersible pump can get.

The fastest way to prime a shallow-well jet pump is to ignore manufacturers' instructions (pull the priming cap, pour water in, turn the impeller by hand to rid it of any air bubbles, replace the cap, start the pump, and repeat as required) and reach for fast-acting Max's Amazing Easy Prime (see Chapter 12).

Total head: Good for lifts up to 25' (7.5 m), discharge heads averaging 130' (40 m) with a 15' (4.5 m) lift.

Deep-well jet pumps: For that extra lift

Unfortunately, water is not always available within a 25' (7.5 m) lift from the pump. One solution to this predicament is the deep-well jet pump. If you fight your way through the cobwebs

in the basement or pump house and happen to stumble across a deep-well jet pump, other than an extra pipe connected to the pump's impeller casing, you wouldn't notice much of a difference from its shallow-well cousin. What differs most between the two is something you can't see: A deep-well jet pump's injector is submerged in, or positioned close to, the water source.

When water is being drawn from a lake, a river, or a well of 4" diameter or greater, the deep-well jet pump system employs two pipes running between the injector and the pump – one for the incoming water (the delivery or suction line) and the other for the water being recirculated back to the injector in its remote location (the pressure or return line). At the injector end, the two pipes join in a Y-shaped housing. The leg of this Y points down and incorporates a foot valve. The recirculated water flows down the pressure line to one arm of the Y, where it makes a 180° turn to head up the other arm of the Y back towards the pump. At the turn, it passes through the venturi, creating a low-pressure area at about as close to the end of the delivery line as you can get. Atmospheric pressure acting on the source water pushes the water through the foot valve into the remote injector (technically, suction head only encompasses this distance between the foot valve and injector venturi), where it joins the recirculated water, passing through the venturi and, presto, velocity decreases and pressure increases (just as it would with a shallow-well system). The water sent down the pressure line, through the injector, and subsequently back up the delivery line is being motivated by pump pressure, which is considerably greater than what your local atmosphere can muster. This is the force that carries the incoming water back up to the pump, which explains why the vertical rise of a deep-well jet can exceed the 25' (7.5 m) maximum lift of any shallow-well pump.

But as lift increases, the quantity of water recirculated down to the injector must also increase, which reduces pressure on the discharge side of the pump. When the lift reaches about 60' (18 m), the water decides it's easier to head for the kitchen tap than to deal with these long-

distance push-ups. Robbed of sufficient pressurized water, the injector can't do its job and the flow stops. To keep enough water travelling back down to the injector, a control valve is added to the discharge side of the pump, between the pump and the pressure tank. Its purpose is to create sufficient back pressure to force the required quantity of water back down to the injector. (It's sort of like an attendant standing outside the parking lot closest to the restaurant you're headed for, waving most of the cars by but letting the occasional one in as space becomes available. If you don't get in, you drive around the block again, building up pressure.) With this valve, a deep-well jet pump's potential lift can be doubled. Unfortunately, because so much of the pump's water, and therefore pressure, is used just to get the water to the tap, deep-well jet pumps are not the hot set-up for killer showers when lifts exceed 60' (18 m).

For low-yield wells, a 35' (10 m) tailpipe is added to the leg of the injector. This simple gizmo gradually decreases the amount of water being pumped as the level of the well drops, preventing the water line from dropping below the foot valve and therefore losing prime.

Wells less than 4" in diameter but greater than 2" can use an inner pipe injector (or packer jet) that employs the annular space between the delivery line and the well casing as a pressure line, the working principles being the same as the standard double line. Some older drilled wells have 2" casings. For driven wells like sand points, where the lift is greater than 25' (7.5 m), there is no other option if you want an electric pump. (The well liner is too small in diameter to house a submersible pump.)

The deep-well jet pump is a real nuisance to prime and is not self-re-priming. Both pipes must be kept full of water for the pump to work, and both must be manually filled as part of the priming procedure. Check your manual for the details specific to your preference in brand and clear the area of children and other innocents. A foot valve is essential for all deep-well jet pumps.

When the pump is offset from the water source by more than 40' (12 m), calculations

for head loss for this dual pipe system get a little weird but, fortunately, each pump manufacturer supplies charts to make choosing the right pipes almost easy. Installation, however, is another matter. If installing those pipes through a well casing, the pitless adapter must be of the type designed to accommodate two pipes. Financially, a deep-well jet pump and all its related paraphernalia will set you back at least twice that of its shallow-well cousin, the cost rising in proportion to the lift and horizontal run required. Because of the difficulty in priming a deep-well jet pump, its expense, rarity, and the minimal pressure it yields with lifts over 60' (18 m), this permutation of the centrifugal pump is quickly being replaced by the submersible pump. Fortunately, those twin pipes can make the switch over relatively easy, one pipe being used as the intake line, the other as a conduit for the electric cables connecting to a submersible pump.

Total head: Good for lifts up to 120' (36 m), discharge heads averaging 40' (12 m) with a 60' (18 m) lift.

SUBMERSIBLE PUMPS: THE UNDERWATER WONDERS

For about the same amount of money as a deep-well jet pump costs you can get a submersible pump. Because the entire pump is immersed in water, a submersible never needs priming. Better-quality submersibles are designed to handle suspended sand and turbid water without suffering severe wear. (The sand will still wear away at seals and impellers, but it takes much longer for the parts to fail, at least in theory.) Submersibles are essentially maintenance free, have a long life expectancy, and are capable of pumping high volumes of water.

Undoubtedly, the submersible pump is the best pump to use when lifts exceed 25' (7.5 m). Because the pump attaches to the submerged end of the delivery line, all the water is being delivered with the full force of the pump. In other words, the pump is pushing the water the entire way to the house or cottage – atmospheric pressure only has to push the water into the spinning

impellers. Suction head is therefore negligible; discharge head equals total head (that certainly takes the figuring out of it), and the total head can be quite substantial.

The submersible pump is a multi-stage centrifugal pump, which means it has a series of impellers and diffusers stacked together, each additional stage benefitting from, and adding to, the previous impeller's work. Generally, more impellers mean greater pressure (and therefore potential discharge head), lower volume, and higher cost. Physically, it's usually a 2'–4' (0.6–1.2 m) long tube (more stages means more length) 4"–6" (10–15 cm) in diameter, a hot-dogular shape that allows it to be lowered down a standard drilled-well casing if need be.

While surface-mounted pumps rely on air circulation for cooling, the submersible depends on the flow of water being drawn past the motor. When the flow rate drops below the manufacturer's specifications, the motor can overheat and burn out. In a drilled well, this is not usually a concern since the water drawn into the pump must squeeze between the pump body and the well casing, the speed of flow past the motor therefore increasing (just as the speed of water flow increases as it passes through the venturi in a jet pump injector). However, in a large body of water, even though the quantities of water are great, the speed of the water passing by the motor is much reduced. Also, in surface sources

such as lakes and rivers, the temperature of the water can get quite warm during the summer months. The solution is to install a flow-inducer sleeve (see box, below).

Electrically speaking, there are two types of submersibles: the 230V and 115V pump, each of which comes in either three-wire or two-wire variants. If the pump is more than 90 m (300 ft.) from the main electrical panel, a 230V circuit is a must due to electrical losses in the wire (similar in concept to head loss in water pipes). And, all other things being equal, a 115V motor does not run as efficiently as a similar 230V motor and therefore will (at least in theory) cost a little more to operate and wear a little quicker. Whether anyone will notice the difference is debatable. (Gosh knows I've debated it long enough with several disagreeing experts, and that's as close to a definitive answer I can get on this planet.)

While some jurisdictions demand that submersible pumps be wired by an electrician, should the situation permit it, the two-wire 115V submersible is the way for the do-it-yourselfer to go because it's much easier to install. This is especially true of submersibles installed in lakes or rivers, when a GFCI (Class A Ground Fault Circuit Interrupter) is required. The GFCI, which monitors the flow of electricity and shuts the power off if any leakage is detected, protects swimmers from the ever-unpopular death by electrical shock. A run-of-the-mill 115V GFCI outdoor outlet can be located at the water's edge, which is easier and less expensive to install than wiring the main electrical panel for a 10 milliamp 230V GFCI, a task I would have serious reservations about suggesting the average handy-person tackle. With good instructions (which your plumbing-supply store should supply), the 115V pump could even be installed by a lawyer. Well, maybe it's not that simple, but you get the idea.

When any motor starts up, its rotating bits try to rotate the motor's housing, which is why terrestrial pumps (and car engines, for that matter) need to be bolted in place. Unfortunately, this is not usually possible with a submersible pump. So to prevent that initial twist from unduly stressing attached pipe and wire connec-

BE COOL: GO WITH A FLOW INDUCER

A flow-inducer sleeve installed over the pump (picture a family-size bean can being slipped over a smaller one) duplicates the water-flow characteristics of a pump sitting inside a well casing. The sleeve is usually made from a stainless-steel tube, or piece of ABS or PVC plastic pipe, the discharge end plugged with a cap that's drilled out to accommodate the pump's discharge pipe and electrical lines. At the intake end, a stainless-steel or plastic screen will keep out the creepy-crawlies, minnows and frogs (sometimes a perforated sleeve wall replaces the screen). In addition to helping keep the motor cool by speeding up the flow of water past it, the sleeve will also protect the pump from getting bumped by rocks, boats, swimmers, and that large fish that got away. In a dug well, because of its confined space and cooler temperatures, the flow-inducer sleeve may not be considered necessary.



Underwater wonder:

When lifts exceed 25 ft. (7.5 m), a submersible pump is the way to go. Submersibles can be expensive, but for your money you get a quiet, true self-priming pump, that delivers high volume and high pressure over a long working life.

tions, the pipe directly above the pump will often run through either a centring guide just before the pipes exit the well via a pitless adapter, or a torque arrestor if the pipe exits through the well head. In a lake or dug well, the pump's usually on its own.

Regardless of voltage or number of wires feeding its motor, a submersible pump is the most problem-free of all motorized pumps, the most efficient, and the most likely to bowl you

over in the shower. In common with deep-well jet pumps, submersibles tend to increase in price in direct proportion to lifts.

Total head: Depends greatly on the number of impellers. A typical 8-stage pump offers a potential discharge head of 125' (38 m), a 15-stage 465' (142 m), and so forth, some models boasting a total head of more than 2,000' (600 m). For any given pump, the deeper the water, the less output (rated in US gpm or L/m).

YOU GET WHAT YOU PAY FOR: THE ECONOMIC REALITIES OF QUALITY PUMPS

Regrettably, the pump most likely to give you the most years of trouble-free service is probably one of the more expensive models. The sad fact is, better design, better workmanship, and higher-quality materials usually cost more.

In a jet pump, look for what is called a double-ball-bearing motor, meaning the motor's shaft rides in ball bearings at each end. Cheaper pumps usually have a sleeve bearing at one end of the motor with a ball bearing at the other. Ball bearings reduce friction, which usually translates into longer life. If the motor's shaft is stainless steel instead of cold-rolled steel, so much the better.

Dampness is a piston or jet pump's nemesis. These motors rely on air for cooling. Humidity in the air gets into the motor and corrodes the inner workings. Submersibles, though immersed in water, don't have this problem since the motor is sealed to eliminate direct contact with the water. Next to moisture, heat is the big enemy of electrical components. Like the flow of water through pipes, the flow of electrons through wire creates friction, which in turn generates heat. Because heat destroys the insulated coatings of wire and the wire itself, all things electric go into self-destruct mode as soon as you turn them on. How quickly this happens depends on many things, including the choice of material for wire or other electrical components.

Most less-expensive pumps use aluminum wiring, which heats up very quickly (which explains why it has been banned for use in most new-home construction). More-expensive pumps often use copper for the areas of greatest load (and therefore greatest potential heat build-up), reserving the less expensive aluminum for lesser duties. Because copper wire conducts electricity more efficiently, it runs much cooler, so copper wire is less apt to be at the cause of motor failure.

Big bolts are another nice feature to look for – and one you can actually see without hav-

ing to ask a salesperson. Big bolts are especially welcome in places that come in contact with water, such as those that protrude into the impeller casing of a jet pump or water box of a piston pump. Small bolts and nuts don't afford sufficient leverage for undoing when rusted in place after 10 years of faithful service. Should you ever feel disposed to take your pump apart in order to replace a seal or whatever, you won't take much notice of hefty bolts. However, your attention will be quickly focused on lesser bolts and nuts that snap or strip as you try to fix a pump cloistered in a claustrophobic crawl space when the sun is shining for the first time this week. (Mind the tongue, children may be near.)

There are genuine differences in pump quality, most of which even the uninformed can ferret out by asking questions and looking beyond the price tag. Cheaper pumps will work, and may last a lifetime. Me, I'm not much of a gambler. I bought a good pump with a well-known reputation for quality from a local dealer I know will be around to service the pump and offer installation or troubleshooting advice if ever required.

BUCKETS OF ALTERNATIVE ADVICE

Our property has two residential buildings on it, the original cottage and an eternally-in-progress year-round home. When the decision was made to build the latter, we decided to move full time into the former because of the obvious convenience of living in close proximity to the construction site.

The cottage has no indoor plumbing. Rain barrels exceed wash water demand in the spring and fall, with drinking water and supplemental wash water drawn from an artesian spring. The spring lies about 60 m (200 feet if you're walking) beyond the outhouse, tucked in behind a 30' (9 m) high outcropping of bedrock. Even when the official outhouse thermometer dares to touch the minus 40° mark, the water in the spring still flows. There is a peculiar and undefinable pleasure derived from going to get water at these times, the silence of winter broken only

by the sound of snowflakes murmuring under the soft sweep of snowshoes, each step dragging work and play closer to a shared definition.

We spent our first winter with a make-shift spring box and no pump. We slid the top of the spring box aside and scooped out a bucket of cold, spring water. The buckets we used (humanity having long ago discovered that it's far easier to carry two heavy buckets than to struggle with the imbalanced load of one) were plastic food-grade 2.6 US gal. (10 L) pails that first saw duty at the local bulk-food store. The lids snap on tight, preventing the water from spilling out during transit. Back at the cottage, the water got decanted into either glass jars (drinking water) or a large plastic water container blessed with a tap (supplemental wash water). Whenever the thermometer stayed on the warm side of the freezing mark, we stepped out the back door and dipped a pot into the rain barrel, heating the water for washing.

Had we been aware from the outset that this routine would stretch out for nearly three years, no question we would have taken a pass, thank you very much. However, the experience wasn't really that bad. Honest. Hauling your own water makes you aware of how much gets used, and how little you actually need. You become part of the system, not just a detached, unquenchable consumer.

Even cottagers with electricity shouldn't dismiss hauling water from a lake, river, or well before considering whether its merits can mesh with the owner's lifestyle. A bucket patrol eliminates the cost and maintenance of pumps and pressurized plumbing. Humans can be quicker to coax (or threaten) into service each spring, don't need to be drained for the winter and, even when not in their prime, are still able to move water. It's a proven, time-honoured tradition. It's also a bit of work, and makes wintertime hot showers all but impossible. So we got a pump for the new house.

But when we finally get around to constructing a log cabin back in the woods (project #5,397), there won't be a pump in sight. Although, maybe a windmill...

Alternative advice addendum

Since writing the first edition of *Cottage Water Systems* in 1993, our cherished spring twice ran dry. The first time, in the midst of an unusually rain-starved summer, nearby longtime residences expressed shock, having never heard of it running out of water before. In fact, they had occasionally come to the spring to get water when their own wells choked during dry spells. So we wrote it off as a quirk, and sure enough, a couple of weeks later water was spewing forth once again and all was well (pardon the pun). Then, two years later, it happened again, only in late fall, a traditional rainy season here but not that year. Call it climate change, a second coming of the quirk, doesn't matter; by any name, we needed a new well for a reliable water source. So we had a drilled well installed.

A drilling machine is a noisy device, what with the roar of the engine and the pounding and grinding of rock. But the sound a property owner hears most is the sound of money sinking down a hole. At about the 220' (67 m) mark, the drillers struck water, but not in sufficient quantities. So the drill started up again, roar, bomp-bomp-bomp, grind, kajing-kajing, finally stopping at 282' (86 m). The closest neighbouring well is about 400' (122 m) away, 290' (88 m) deep, and produces loads of excellent water. The new well's static level quickly rose to 17' (5 m), with a drawdown to 22' (6.7 m) after four hours of continuous pumping, an imposition that would never happen in any real-life situation. So despite it being a deep well, we were still able to use the same jet pump we had to pump from the spring, saving us a few bucks and a bit of work. Unfortunately, the quality isn't as good as we expected, our well water being burdened with iron. While our neighbours with a well of the same depth can use their water without treatment, we had to install an iron removal system (see Chapter 6).

The funny thing is that, despite now having no restrictions on water consumption, we still conserve, knowing that every time the pump goes on, it costs us money as some electrical plant delivers its volts, and every time we

send water down a drain, the septic system and environment has to deal with it. So the lessons learned from hauling water by the pail and using an outhouse carry on, without sacrifice or hardship. And the spring box and outhouse still get used on occasion.

MORE OFF THE ELECTRICAL GRID OPTIONS

Besides hauling buckets, or using hand pumps or wind-powered pumps, those not hooked up to the electrical grid also have the option of using a low-voltage (12V–32V) version of almost any of the other pump types discussed here, or

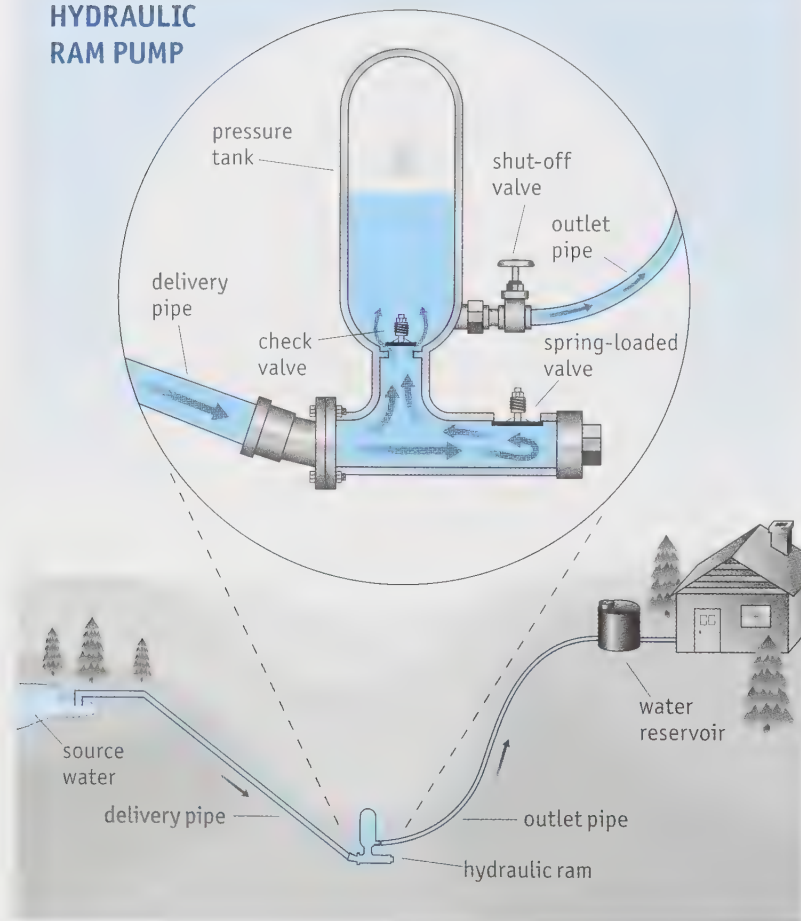
variations of 120V–240V submersible pumps designed to operate using an inverter (which converts lower voltage upward, or vice versa). Typically, all these pumps get their power from photovoltaic panels capturing energy from the sun, windmills doing the same from the wind, batteries, a small generator, or some combination thereof. Most of the low-voltage pumps offer a correspondingly lower output, which diminishes even further as the sun or wind takes a break. Because of this modest output, most low-voltage pumps are not compatible with pressure tanks. So rather than operating intermittently on demand, low-voltage pumping systems work best whenever nature is providing the power, letting the water fill a reservoir at its leisure. If you need pressure, most variations do a respectable job of pushing water, both horizontally and vertically, which makes it possible to fill a water tower. If putting up a tower won't work in your situation, battery-operated booster pumps can also increase water pressure when you need it (such as a shower after a day of working up a sweat, preferably from lying around soaking up energy from the sun).

WATER-POWERED PUMPS

If your water source, such as a lake or river, is situated near a downward slope, you can use the downward flow of the water to pump water up to even greater heights, such as to a reservoir, and from there, to your taps. The trick is to convert the high-volume, low-pressure downward flow of water into a low-volume, high-pressure upward flow, keeping the reservoir topped up much as you would with a low-voltage pump.

The hydraulic ram has been doing this for centuries. With modern versions, a long, large diameter pipe carries the source water downhill to the ram. Here, the water flows past a spring-loaded valve, flowing through the ram until sufficient flow and pressure force that valve shut. This creates a sudden and dramatic increase in pressure (the “ram”). With the easy exit now closed, the force of the ram and incoming water push the water up into the small diameter outlet

HYDRAULIC RAM PUMP



An ancient concept for modern times:

The hydraulic ram pump uses gravity to convert high-volume, low-pressure downward flow into low-volume, high-pressure upward flow by harnessing the energy of the water itself. Averaging 50% efficiency (half of the source water is wasted) these devices are relatively inexpensive and have zero operating costs.

pipe, its flow redirected uphill to a storage reservoir. This escape in turn dissipates the effect of the ram and the pressure drops, the force of gravity then causing the water in the outlet pipe to start flowing back downhill. This returning water quickly causes a check valve in the outlet pipe to close, leaving the pipe full of water and ready for the next upward push. Meanwhile, in response to the reduced pressure in the ram, its spring-loaded valve reopens to let the source water flow downhill out the exit again and, voilà, the whole process starts over, merrily repeating as often as the force of the downward-flowing source water is strong enough to close that spring-loaded valve.

Because the initial shock, or ram, created by the closing of the spring-loaded valve can be strong enough to burst a pipe, a pressure tank – similar in concept to that used in a pressured system (see Chapter 4) – is usually installed to help mitigate the ram effect. But the tank must come after the water is headed for the smaller outlet pipe, not before, which means that the inlet pipe must be rigid, as in metal or ABS, not the ubiquitous polyethylene pipe used for most rural intake lines. (See Chapter 4 again.)

Still newer water-powered pumps use a slightly different means to accomplish the same thing, though slightly more efficiently. For instance, the High Lifter uses a single cylinder of two diameters, the inlet end larger than the outlet end. Inside, two pistons, sized to match the cylinder's differing diameters, are joined by a single connecting rod running between them. So when one moves back, the other moves forward, and vice versa. When source water charges into the cylinder's larger end, the larger piston is pushed forward to make room for the water. Once the piston reaches the end of its travel, the incoming water is diverted around it, reducing the pressure against it. Meanwhile at the other end of the cylinder, part of that diverted water is directed into the smaller end, thereby pushing the smaller piston back (the pressure on the larger piston reduced after the force of the incoming water was diverted around it). This in turn pushes the large piston back and the process starts over. The

part missing here, and only in the telling, is that when the large piston is pushed forward, the water in the smaller cylinder is forced into an outlet pipe, typically leading to a reservoir. So the volume in the large chamber is converted to pressure by forcing the water through a smaller pipe. Or to put it another way, with each reciprocating action of the pistons, a portion of the diverted water is rerouted into the outlet pipe for the next push up.

The efficiency of water-powered pumps averages around 50%, meaning that about half the incoming water doesn't make it to the outlet pipe. This is the energy cost, free or otherwise. The High Lifter requires much less incoming flow than a hydraulic ram to operate, but is just as happy when water input is abundant.

In common with any water system, all off the electrical grid solutions – including the bucket brigade – must be protected from freezing.



The art and
science of intake
lines

Repairing cracks
and splits

Strainers, foot
valves, and check
valves

Lightning
protection

Options for
interior plumbing

Guide to plastic
pipe

Pressure tanks
and switches

Waste lines

Troubleshooting
guide

4. HOOKING UP THE SYSTEM

From the source to your shower – it's all about connections

PLUMBING IS A PARTNERSHIP of opposites:

the supply system and the waste system. The supply system consists of two sub-systems – the delivery system and the inside pressure system – while the waste system is everything on the exit side of the plumbing, even if it's pressurized (like a sewage pump, for instance). For water to complete the loop from earth to your tap or toilet and back to earth, each component of the water system must be doing its part. Failure at any point can threaten not only the frivolous stuff such as having a shower and flushing the loo, but also the essentials, such as producing hot water for tea or ice cubes for lemonade.

A typical supply system could include (not necessarily in this order) a strainer, foot valve, supply line, check valve, pump, line out of the pump, sediment filter, pressure tank or reservoir, and water-treatment device, followed by the usual maze of indoor plumbing we have come to ignore or despise. Since the mechanics of piecing pipes together are covered in countless other books, such

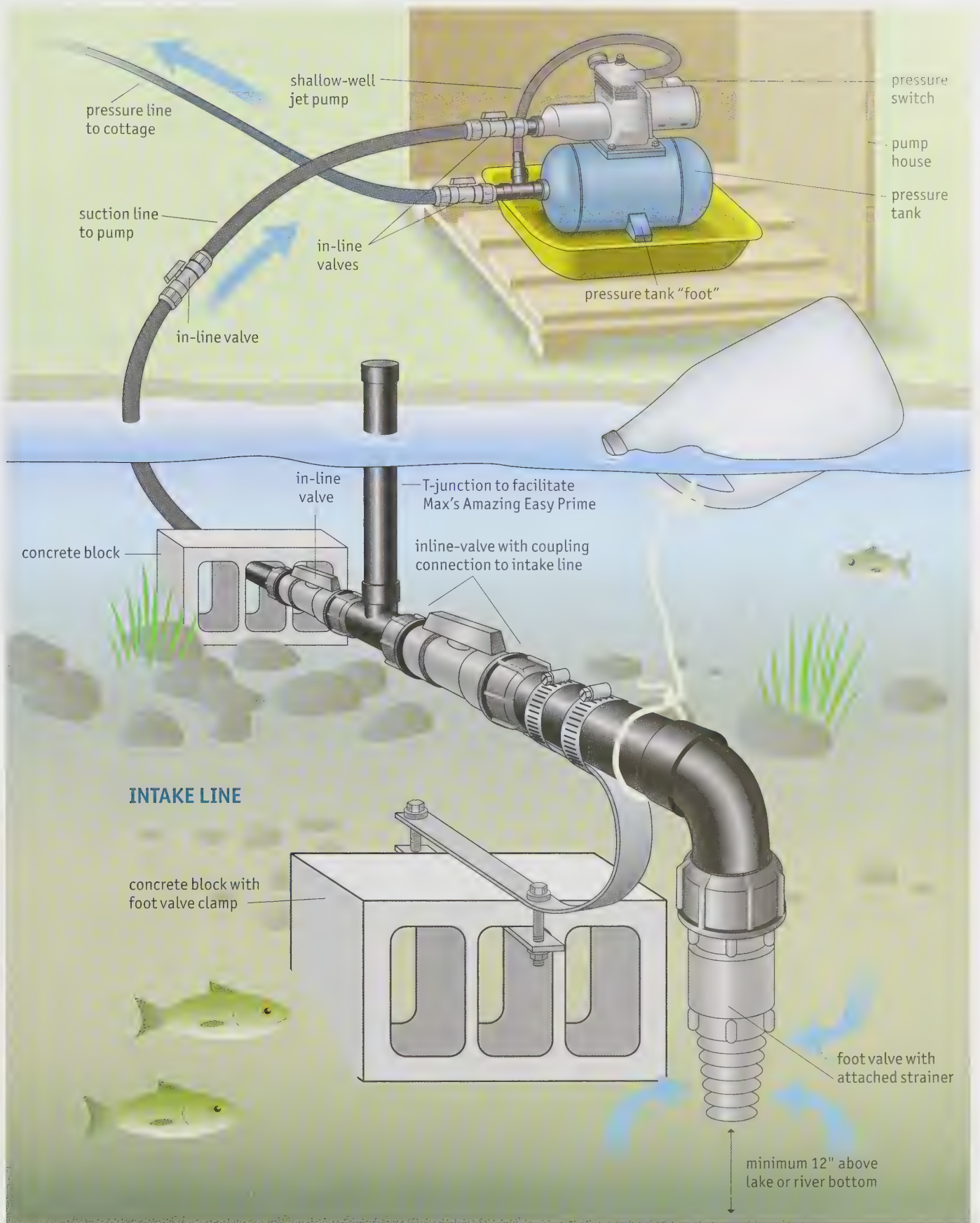
basics will be left to those journals. Instead, the focus of this chapter is on the idiosyncrasies specific to off-the-plumbing-and-sewage-grid water systems, most of which are overlooked or barely mentioned in general how-to books.

THE INTAKE LINE

Atmospheric pressure doesn't only exist at the end of an intake line, pushing the water up the pipe; it exerts the same pressure along the total length of pipe. The majority of problems related to maintaining the pump's prime can be traced to the intake line running between the water source and the dwelling. When this line depends on the low pressure established in the pump to

The secret to system setup:

Most problems related to maintaining the pump's prime have their roots in the intake line: If the pump can't draw water in, it can't pump it out.



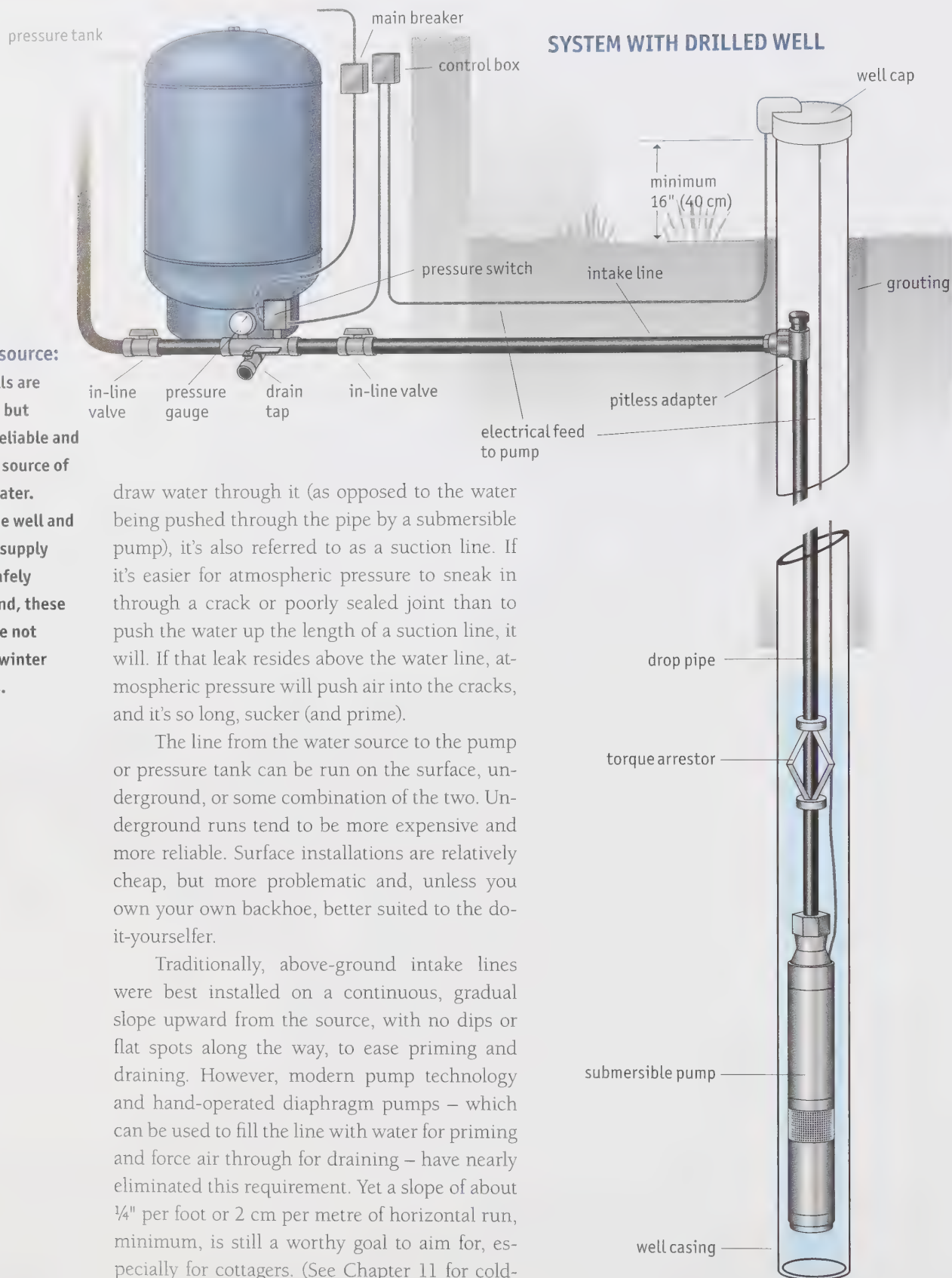
SYSTEM WITH DRILLED WELL

Superior source:
Drilled wells are expensive, but provide a reliable and consistent source of drinking water. Because the well and all related supply lines are safely underground, these systems are not subject to winter freeze-ups.

draw water through it (as opposed to the water being pushed through the pipe by a submersible pump), it's also referred to as a suction line. If it's easier for atmospheric pressure to sneak in through a crack or poorly sealed joint than to push the water up the length of a suction line, it will. If that leak resides above the water line, atmospheric pressure will push air into the cracks, and it's so long, sucker (and prime).

The line from the water source to the pump or pressure tank can be run on the surface, underground, or some combination of the two. Underground runs tend to be more expensive and more reliable. Surface installations are relatively cheap, but more problematic and, unless you own your own backhoe, better suited to the do-it-yourselfer.

Traditionally, above-ground intake lines were best installed on a continuous, gradual slope upward from the source, with no dips or flat spots along the way, to ease priming and draining. However, modern pump technology and hand-operated diaphragm pumps – which can be used to fill the line with water for priming and force air through for draining – have nearly eliminated this requirement. Yet a slope of about $\frac{1}{4}$ " per foot or 2 cm per metre of horizontal run, minimum, is still a worthy goal to aim for, especially for cottagers. (See Chapter 11 for cold-weather variances.) While it's possible to force



the water out of a roller-coasteresque line at season's end, why use elbow grease when gravity will do the job? For shallow-well pumps operating without foot valves (more on these valves later), a sloped self-draining line remains a must.

For full-time residences, none of this really matters, the intake lines needing priming only once at initial start up (barring any surprise failures), and draining of the lines is for other people with way too much time on their hands.

CHOOSING AND INSTALLING AN INTAKE LINE

Black polyethylene pipe (PE, or poly to its friends) has become *de rigueur* for cottage and rural intake lines, all but replacing corrosion-prone metal pipe. In fact, if your water is the least bit acidic, you should never use galvanized metal pipes or fittings. Up to 1% of the galvanized coating can be lead, used in part to improve the viscosity of molten zinc as it is being applied to a metal surface. Aside from potentially leaching lead, galvanized pipes tend to rust on the inside, reducing their inside diameter and restricting flow.

In Canada, look for the CSA approval stamp on the side of poly pipe, and in the US, the ANSI, ASTM, or NSF stamps, though approvals from all of these testing organizations are increasingly becoming accepted on either side of the border. Poly is also graded by its maximum-allowable pressure rating. The higher-rated pipe has thicker walls and is therefore a little more difficult to handle, but it is substantially tougher, and subsequently longer-lasting and more resistant to damage. Some jurisdictions, such as Wisconsin, won't permit anything less than 150-psi poly for suction lines; others exempt owner-occupied, single-family dwellings on private water systems from the plumbing code entirely. While lax laws may open the door to low-grade (or utility-grade) poly, don't be tempted – the savings are simply not worth the aggravation. The more often you stress a pipe to its design limits, the sooner it will fail and transfer that stress to you. In most cases, an approved, 100-psi, 1"–1½" diameter intake line will do the job nicely (1" or 1¼" being the norm).

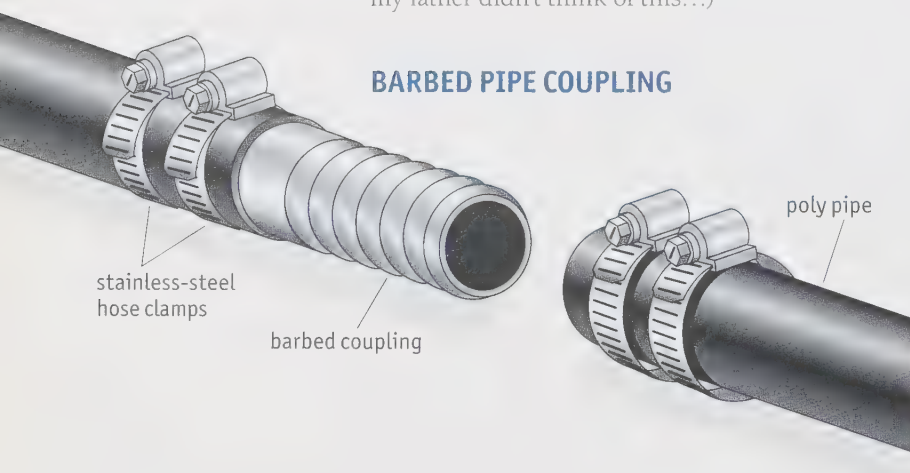
Whether you run the intake line above ground or below, it's a good idea to run it through an outer protective shell, like 4" diameter corrugated plastic drain pipe, referred to in my part of the world as Big 'O'. This sleeve is inexpensive, curves easily around 90° bends, keeps the sun off the inner pipe (sunlight degrades plastics), and stops the poly and joints from chafing against rocks and such. If the line is buried underground, the sleeve prevents rocks or sand from caving in around the pipes. This means you can pull the poly out of the sleeve should repairs be required, and then feed the poly back in without having to dig up the whole mess. (None of this applies where regulations call for concentric piping, where the buried suction line is enclosed in a larger pipe filled with water pressurized by the house or cottage system.)

Unfortunately, trying to coax poly through corrugated drain pipe is a great way to increase blood pressure as you discover new ways to rant and curse. To make the task decidedly less stressful, cram a large caster into the end of the poly, or use a sand-filled soft drink bottle, securing either in place with tape and a self-tapping screw. The caster or bottle encourages the leading lip of the poly to slide over the corrugations instead of getting hung up on each and every ridge. Feeding the poly into the sleeve is best accomplished with two teams – one pushing the poly, the other dragging the sleeve over top. (Up our way, we're trying to get this popular activity recognized as an official Olympic sport. Or at least as part of the annual fall fair.)

Since joints are the most probable points of potential leaks, the ideal intake line should be one continuous pipe, with connections only at each end. Admittedly this can be difficult to achieve for cottagers with overland lines that might need to be rolled up for winter storage but even then, the fewer joints, the better.

Because the specific gravity of PE is slightly less than water (0.95 versus 1.0, if you must know), poly pipe possesses a modicum of buoyancy. If the suction line terminates in surface water, the conventional way to keep the pipe secured and submerged, and not floating or drifting aim-

...sly about like a teenager on a Saturday night, is to run the line through a concrete building block every 3' (1 m) or so. (Unfortunately, this won't work for teenagers as the holes in the block are too small, though that didn't stop my father from trying.) Although convenient, concrete blocks can be abrasive, slowly wearing away at PE pipe as the intake line gets bumped about by underwater currents and storm action. If this is a concern, and the intake line isn't just a seasonal installation (see Chapter 12), instead of using blocks, place bags of dry pre-mixed concrete over the line at the same intervals. As the bags absorb water, the concrete cures to the shape of what lies beneath it, pipe and submerged lands included. (Good thing my father didn't think of this...)



BARBED PIPE COUPLING

Classic

connection:

A barbed coupling secured with doubled-up hose clamps is a time-tested pipe joiner. Easy to install after heating the poly pipe with hot water or a hair dryer, they are almost impossible to remove without damaging the ends of the intake line.

JOINING INTAKE LINES

The usual method of joining poly to pump or poly to poly is to use a barbed coupling (threaded on one end when connecting poly to a pump, barbed on both when connecting poly to poly). A barbed coupling works like a fish-hook or an arrow head – it slides in (with a bit of work) but has slanted rings whose sharp edges grip the inside of the pipe when you try to pull it out. Traditionally, these barbed coupling were made of metal, and secured to the pipe using stainless-steel worm-drive joint clamps, two for each barbed end of the coupling. They're called worm-drive because the screw sort of crawls along a row of slits cut into the clamp, but they're usually sold simply as hose clamps. You can get away with one clamp

on each end of the coupling, but doubling up makes the joint much less likely to leak, and the extra expense is minimal. Slip the slack clamps onto the pipe first, then slide the pipe over the coupling. Pouring hot water over the end of the pipe prior to this makes the plastic more pliable and easier to force onto the coupling. (A hair dryer will also do the trick if hot water is not available.) Tighten the clamps, and you're done. (Always test the joint for leaks before burying or installing in an outer sleeve.)

So much for tradition. A newer and better version of the barbed coupling is the Hanflo poly-pipe coupling. Made from fibreglass reinforced nylon, it forgoes hose clamps, replacing them with a large nut permanently attached at each end of the barbed coupling. (There are also versions that are threaded at one end for easy attachment to pumps and foot valves.) Tap or wiggle the fitting into the pipe, just as you would for the metal barb, except instead of messing about with hose clamps, you simply turn the nuts. The nuts self-thread onto the PE pipe, pulling the pipe back onto the coupling for a tight compression fit. Easy, all for about the same price as the four-hose-clamp and barbed coupling combo. So where's the catch? The psi rating of the poly pipe. Remember that the higher-rated pipe has thicker walls? Thicker walls don't reduce inside diameter of the pipe but instead, increase the outside diameter. The only time you're likely to notice this is when installing a Hanflo fitting. Each Hanflo fitting must match both the pipe size and psi rating of the pipe it is being joined to. Wrong psi, the nut won't tighten properly on the poly and therefore the joint will almost certainly leak. Because poly pipe doesn't always have its rating marked on the outside, or the markings might have worn off over time, choosing the right fitting isn't always as easy as it should be. So if you aren't certain of the pipe's rating, at least make sure you can later exchange the fitting for the correct one (and that you aren't in a hurry to get the water flowing).

No question, my favourite way to join sections of intake line is the quick disconnect poly-pipe fitting. Both Hanflo and Philmac market

such a fitting, either version disconnecting and re-connecting as often as you've a mind to do it. Turn a nut to connect or disconnect sections of pipe and leaks from cracked pipe at the connection are virtually eliminated. Both companies offer fittings in a wide variety of T-junctions and elbows to suit most intake line needs. The Hanflo version also allows one end to swivel over a 9° arc, which can make connecting pipes disinclined to align a little easier. But as with Hanflo barbed couplings, Hanflo quick disconnect fittings must also be matched to the psi rating of the pipe. Not so with the Philmac fitting (or ye olde metal barbed fittings, for that matter). I have used both types, the Hanflo quick disconnect fitting for irrigation lines, not pressure lines, and the Philmac fitting in all sorts of places, including buried 6' (2 m) underground. With the Hanflo, the attached pipe must be able to rotate to easily disconnect, but not with the Philmac, its process so simple a politician could do it without even having to establish a committee to study the matter first.

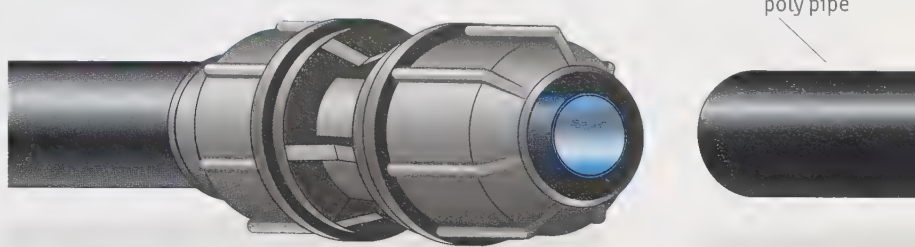
With either brand, repairs to an intake line can be made underwater, in the winter, or both if you're seriously masochistic. Cut out the cracked section of poly, wiggle the ends of the fittings into the pipe, and bolt them together, no gluing or heating required. That's the good news. The bad news is that the complete line of either Hanflo and Philmac fittings are unlikely to be stocked by your favourite local plumbing supply store. So nag them, because the stuff's worth the higher price.

REPAIRING LEAKS IN THE INTAKE LINE

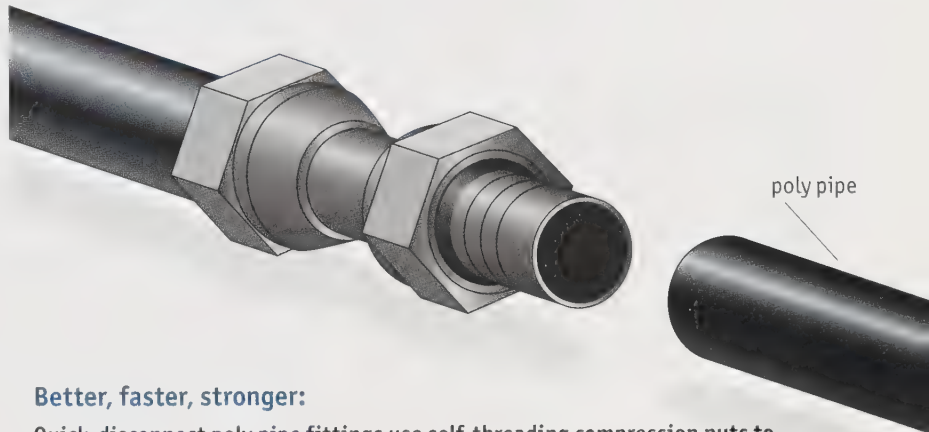
The most frequent culprit for leaks is any connection, whether pipe-to-pipe or pipe-to-object (such as a pump or foot valve). Plastic compression fittings, such as the Hanflo or Philmac, are less likely to leak than their metal-and-clamp counterparts because they are typically designed to withstand pressures far exceeding the limits of the attached pipe. That said, any barbed couplings, metal or plastic, becomes even more cul-

pable whenever it is disconnected (such as a cottager might do when storing the intake line for winter) as poly pipe has a tendency to crack when a barbed coupling is yanked out of it. Leaks can also result from the pipe being stepped on or run over, or simply from old age. Whatever the cause, cracks or splits in poly have to be cut out (a hacksaw works well for this task) and a new piece spliced into the remaining good sections of pipe. If a leak finds you short on extra pipe and cou-

PHILMAC PIPE COUPLING



HANFLO COUPLING



Better, faster, stronger:

Quick-disconnect poly pipe fittings use self-threading compression nuts to allow you to easily attach and detach intake lines for storage without damaging the pipe. Hanflo fitting must be matched to the size and pressure rating of the pipes they connect; Philmac fittings do not.

plings and long on visiting relatives, temporary repairs can be made to small splits by wrapping them first in tape (duct tape works best), then a section of inner tube (perhaps liberated from the kid who ran over the pipe with a bicycle?) or some similar squishy substance, and then securing the patch in place with a few hose clamps. Duct tape and spare hose clamps, like bandages and snacks, are cottage and rural essentials.

LOST IN TRANSLATION?

A guide to plastic plumbing acronyms

LETTER NAME	FULL NAME/ ALTERNATE NAMES	COMMON COLOUR	PRIMARY APPLICATION	COMMON JOINING METHODS
ABS	acrylonitrile butadiene styrene	black	indoor waste lines	glue with fittings
PE	polyethylene, poly	black	water intake lines	barbed coupling with worm-drive hose clamp/Hanflo poly-pipe coupling/Hanflo or Philmac quick disconnect poly-pipe compression fitting
CPVC	chlorinated polyvinyl chloride	grey/white	water pressure lines	glue with fittings, designated connectors
PVC	polyvinyl chloride	grey/white	cold-water pressure lines (not hot-water) and outdoor waste lines	glue with fittings, designated connectors
PB	polybutylene (no longer available)	grey	water pressure lines	copper fittings with crimped compression joint
PEX	cross-linked high-density polyethylene	white or blue	water pressure lines	brass fittings with crimped compression joint or O-ring compression fitting
PEX-AL-PEX	aluminum tubing sandwiched between inner and outer layers of PEX, various trade names	blue	water pressure lines	proprietary brass fittings

CONDENSATION

Another popular source for dripping water is condensation. The water in the system is usually colder than the surrounding air. When warm air hits a cold surface, the moisture in the air condenses on that surface. When that surface can no longer hold the condensate, it dribbles off and we get a puddle on the floor. For water pipes, whether on the intake side of the pump or the pressure side, preformed pipe wrap made from polyethylene foam insulation is the answer. This tubular stuff looks like an anorexic swim noodle, except it's hollow in the middle, and there's a slit

running along one side. Cut the length of the insulation to match that of the pipe, pry open the slit with your hands, and slip it over the pipe; it's that easy.

For water tanks and pressure tanks, handy preformed foam wrap isn't readily available. I found a large, flat sheet of ½" (1.3 cm) polyethylene foam at a local plumbing supply shop. With much cutting and cursing, it was coaxed to reluctantly wrap around a tank, secured there with a dozen or so extra-long plastic tie-wraps. This won't work for indoor water pumps, nor will it stop tank condensation on a hot humid day, though it greatly reduces the amount of drip-

ping condensation. The missing link is a drip pan; something for the condensate to collect in and then evaporate into the air rather than make a mess on the floor. Problem is, as of this writing, no one is making such a device. Except you. Time to get creative. Measure the footprint of the device that needs the pan, then go hunting with a tape rule in hardware stores, plumbing shops, home building stores, garage sales, the mess of toys the neighbour's kids left in your yard, wherever. What you're looking for is something that can be converted into a pan, preferably made of thick HDPE (high-density polyethylene) because it will have to be both waterproof and strong. Full water tanks are heavy, and pumps vibrate a bunch; should the pan crack, expect a mini tsunami to charge across the floor.

As an example, for the jet-pump sitting on – and once dribbling on – my workshop floor, a trip to an automotive supply store found a container designed to catch oil as it drained from a vehicle's engine. It was sturdy, HDPE and, with a few modifications, was a perfect fit. I had my drip pan. For tanks, look for something slightly larger than the tank's diameter, such as a heavy-duty plastic drum, or portable water jug. Whatever you manage to dig up, cut it so that the sides are high enough to hold the condensate, typically about 2"–4" (5–10 cm).

WHAT'S ON THE INTAKE LINE

THE STRAINER

At the submerged end of the intake line is (or should be) a strainer. The strainer's purpose is to prevent pebbles and other debris from getting into the water line, all of which can destroy valves and pump seals, not to mention the texture such stuff adds to your drinking water. Sometimes the strainer is incorporated into the foot-valve assembly or, in the case of submersibles, integrated into the pump. Never use a strainer with holes smaller or larger than recommended by the pump's manufacturer.

FOOT AND CHECK VALVES: HOW THEY WORK AND SOMETIMES DON'T

Unless you have a submersible pump, your system will have a foot valve, which will either be attached to the strainer or both devices will be integrated into a single unit. The foot valve is a type of check valve, which permits the water to flow in one direction only (its name is derived from its location at the foot of the system). Specifically, the purpose of the foot valve is to prevent the water in the intake line from draining back to its source, keeping the line full and ready for the next time the pump is called to action. Check valves can be located elsewhere along the line, usually just a bit before the pump or, in the case of a submersible, just after the pump.

When the non-submersible pump starts working, the low pressure it creates will cause atmospheric pressure to push water into the intake line, opening any foot valve or check valve that precedes the pump. When the pump quits, atmospheric pressure stops being so pushy and a spring shuts the valve, assisted by the weight of water held in the line above it. If a foot valve fails, the water drains back into the lake or well. Next time the pump starts up, it sucks on a pipe full of air and the opened taps begin burping and gurgling like mischievous kids belting back a bottle of ginger ale. When a check valve follows the pump (as in the case of a submersible pump), the valve is opened by water pushed by the pump, the valve-spring and water beyond the valve closing it when the the submersible pump shuts off and the pressure relents.

While the foot valve should be kept below the water's surface so the pump doesn't take to sucking air, it should not be left to rest on submerged land. In wells, the valve's position is usually determined by the depth of the suction line and type of pump. But whether in a well or surface water, keep it a minimum of 12" (30 cm) above the bottom and 3' (1 m) below the surface. For surface-water applications, the distance from shore is usually dictated by the water's depth (keeping in mind any seasonal changes in wa-

ter level), the location of nearby docks (with their associated boat droppings), and ease of installation and maintenance.

If the bottom of the lake or river is covered in stones, placing the foot valve within a larger basket or crib will protect it from damage and clogging. You can purchase ready-made foot-valve stands that do a fine job of keeping aqua-trash out, some very simple and inexpensive, such as the water line anchor bracket made by Rintoul's Hand Pumps that secures the foot valve and water line to a concrete building block. Another solution is build your own platform or A-frame structure, the frame anchored in place with rocks. If the bottom is soft mud, the foot valve can be suspended from a buoy to keep it from ingesting the muck. (The buoy also marks where the intake line ends, alerting boaters and swimmers.) But my favourite valve-and-stand solution waits below (no peeking ahead).

One of the best things you can do for a check valve, at the foot or otherwise, is to keep the valve as close as possible to the position it was designed to operate in. For example, in surface-water applications, foot valves are often installed in the horizontal position, parallel to the intake line. However, in most cases if the valve is pointed vertically downward, or at least at a 45° angle, the water col-

umn inside the pipe above it can then help close the valve. This results in less wear on the spring. Also, dirt will be more inclined to fall through the valve rather than getting hung up on the valve seat. Speaking of dirt, even the lowly strainer attached to the foot valve will be less likely to clog if it's kept vertical. And while submersible pumps and injectors on deep-well jet pumps can work fine lying on their sides, most foot valves attached to them prefer not to. Meanwhile, in-line check valves, such as the one you might install on the intake line immediately preceding a jet pump, usually operate best in the horizontal position. (The same goes for me around mid-afternoon nap time, one of the few perks of age.)

Then there's the Hanflo foot valve. With all other foot valves, even when open, the valve (or gate) still sits in the way, the water having to flow around it. With the Hanflo, a diaphragm-type valve steps aside to open, dropping to the bottom of the unit, the rush of water then flowing through the strainer directly into the intake line, largely unimpeded. But that's not the best part. This valve operates equally well at any angle, even upside down. Which brings me to the Han-Stand, Hanflo's cleverly named foot valve stand. With this stand, both the intake line and the stand sit on submerged land, a vertical pipe raising the foot valve about 18" (46 cm) off of the bottom where it sits, upside down. (Obviously, this stand, or concept, won't work with normal foot valves.) The obligatory catch? It takes very little debris and turbidity to stop that diaphragm-type valve from closing properly, leading to leaks and a loss of prime. The solution is to make sure you also use the Hanflo Foot Valve Sock Filter (every foot benefits from wearing a sock in the cold, eh?), which does a great job of keeping the debris out.

And while on the topic of stands, if using a submersible pump in surface water, you obviously need to keep it off the submerged land. You can make your own A-frame stand where the pump sits in an integrated flow-inducer sleeve, but there are a bunch of good ones already on the market, including a model manufactured by Heat-line.

No matter where it resides along the line, more often than not check-valve failure is caused

KEEPING WATER IN LINE

An in-line valve is a tap without a spout, its purpose being to isolate the various sections of the supply system. This makes for faster, less troublesome repair, as you won't have to drain and then reprime the entire system after tending to a localized problem. In many cases, in-line valves permit continued use of the system while a repair is taking place. Use only gate valves or ball valves for this task; the less-expensive conventional types, also known as globe valves, restrict flow even when fully open. This is particularly important on intake lines because any restriction reduces the potential lift. By peering through a gate or ball valve as you open it, you will be able to see the gate lifting or the ball turning. When these valves are fully open, nothing obstructs the view. In contrast, you won't be able to see much through an open conventional in-line valve.

Good places for in-line valves are on both the intake and output sides of the pump, at the pressure tank, and before any fixtures, such as toilets or faucets.

by dirt lodged between the valve and the valve seat (against which the valve closes), or an improper seal at the joint where the line meets the valve. In either case, water will bypass the valve. To test a foot valve or submerged check valve, the line must be hoisted out of the water. Other check valves are usually above the surface and accessible. Inspect for seepage around the joint, looking carefully for cracks in the pipe where it meets the valve.

If there are no apparent leaks at the joint, remove the valve from the line. Hold the valve upright and pour water in the top (with any attached strainer removed if it's a foot valve). No water should pour out the bottom. If it does, you've got a leak. Invert the mechanism, and while holding the valve open, pour clean water through to flush it out. Use an old toothbrush or the tip of your finger to clean the surfaces of the valve and valve seat. Hold it upright and check for leaks again. If the cleaning did not work, then either the spring, seat, or valve itself is kaput, and it's time for a new valve.

LIGHTNING ARRESTORS: A BRIGHT IDEA FOR SUBMERSIBLE PUMPS

The submersible pump requires a peripheral piece of plumbing paraphernalia. Because submersibles are both at the end of the line, electrically speaking, and sitting in water, they are theoretically more susceptible to damage from lightning than surface-mounted pumps. They are also expensive to replace should lightning strike. Therefore, lightning arrestors should be installed at the control box and wherever the pump's electrical lines enter the house or cottage. (On two-wire units the control box, and sometimes the arrestor, is built into the pump.) If the pump sits in a well, install another arrestor at the well head (the top of the well). Ground the arrestor directly to the pump or, if in a drilled well with a steel casing, it can be grounded to the casing as long as it sits within 20' (6 m) of the pump. In addition to the arrestors, the system should be grounded using at least two $\frac{3}{4}$ " x 10'

(2 cm x 3 m) ground rods, driven vertically into the ground, 10' (3 m) apart, the top of each at least 12" (30 cm) below the earth's surface. However, should you live in an area where bedrock prevents driving anything very far into the earth, as I do, $\frac{3}{8}$ " x 2' x 2' (1 cm x 60 cm x 60 cm) ground plates can be used instead, the plates buried to a minimum depth of 6" (15 cm).

Aside from the advantages the two-wire 115V submersible offers the do-it-yourselfer (see Chapter 3), the plumbing-supply store of preference in the village immediately south of me suggests there may be one more reason to go the two-wire route, regardless of voltage. Over the years, the folks in the shop have noticed owners of three-wire pumps coming in for replacement control boxes because the boxes were getting toasted by lightning. The two-wire submersibles, meanwhile, didn't appear to be getting hit at all. Keep in mind that this is an observation in a small area of one country, not a survey conducted using recognized statistical methods. Still, the two-wire pumps seem to have saved the shop's customers a few bucks on post-storm repairs. That said, because the control box on a three-wire pump is not part of the pump, but installed remotely, servicing it does not require removing the pump from the lake or well.

THE INSIDE STORY ON PRESSURE LINES

No question, the submersible pump can certainly confuse the issue of where an intake line ends and the pressure line begins. To limit the confusion, it is hereby declared that in this book the term "pressure lines" encompasses everything from the pressure tank on, though some of the theory will certainly apply to a pressurized intake line (such as the intake line between a submersible pump and the pressure tank).

Pressure lines have the opposite problem to suction lines – the pressure is greater inside than outside. While air pressure outside remains 14.7 psi at sea level, the pressure inside usually ranges from 20–60 psi, but can be substantially higher

for short bursts when a tap is suddenly closed. And, opposite again to a suction line, these pressure differentials are at their peak when the water inside the pipe is at a standstill, not when it's flowing (an open tap providing a release for the pressure). So the water sitting in these lines is under continual pressure to get the heck out of there, any way it can. This is great news if you are about to have a shower, but not nearly as welcome if the water has just found an unauthorized escape route.

CHOOSING PIPE FOR PRESSURE LINES

The word “plumbing” is derived from the Latin *plumbum*, meaning “lead”. From Roman times right up to the middle of the 20th century, lead was considered the material of choice for pipes, primarily because it's watertight and reasonably malleable. However, since the discovery that lead is toxic to humans, and that it leaches out of the pipes into our drinking water, lead is no longer embraced with such enthusiasm. Even the small amounts contained in the soldered joints of copper pipes and fixtures, or used in the process of galvanizing, can be a problem. In fact, in most jurisdictions, the use of lead is forbidden anywhere in potable water lines.

Fortunately, non-lead solders are now commonplace, as are a growing variety of pipe materials. Depending on acceptance by local plumbing codes, you can choose between copper, CPVC, or PEX for interior pressure lines. CPVC (chlorinated polyvinyl chloride) is not the same stuff as PVC (polyvinyl chloride), the latter good only for cold-water pressure lines and waste lines, not hot-water lines. All are available in ½"–¾" diameters, the size of pipe most often used for indoor pressure lines. Keep in mind that ABS (acrylonitrile butadiene styrene) is suitable only for waste lines. (See p. 56 for a plastic primer.)

For decades, copper has been the choice for pressure lines. It's sturdy, durable, and can be cut and joined with a moderate amount of skill. However, copper pipe will corrode when exposed to water having a pH lower than 6.5. The

solution is to either install a water treatment device (see Chapter 6) or use plastic pipe.

For many reasons, plastic pipe is becoming increasingly popular, particularly with do-it-yourselfers. First, it's malleable, and even the fairly rigid CVPC allows you to bend the pipe into gentle curves. This may make the difference between using one continuous piece of pipe or having to cut and join two or three shorter pieces together. And unlike soldered joints, there's no open flame from a propane torch to deal with when joining sections of pipe. But mostly it's the skill levels required: gluing pieces of plastic together is much less challenging than making watertight soldered joints. That said, there are solderless, non-glue compression fittings and connectors for both copper and plastic that make assembling a pressurized plumbing system a snap. Literally. Watertight joints every time, with no fumes and much less work – how could you lose? When you get out your wallet to pay for them, actually. The catch is the cost – solderless connectors will set you back about three to four times more than comparable soldered copper or glued-together plastic fittings. Still, for small repair jobs, they are worth considering simply because of the ease and speed of installation.

If the plumbing job is big, say a new home or an addition, there is an economical alternative; plastic pipe and fittings connected by a crimped compression joint. This process enjoyed widespread use for joining pieces of PB (polybutylene) pipe together, but after experiencing problems with leaks, primarily with the polyacetal plastic insert fittings secured by aluminum crimping bands, the product was removed from the market. Despite the scare tactics issued by some plumbing companies keen to replace a homeowner's entire pressure system, if your water system already has PB pipe using the copper insert fittings with copper crimping bands, and it's not leaking now, it will probably last as long as any other system on the market. Leaks occurring with the PB and copper system are usually the fault of the installer, not the product. Yes, it's true that PB systems will eventually fail, not because they're PB, but because *all* systems will eventu-

PRESSURE TACTICS: THE THEORY BEHIND THE SYSTEM

Pressure is defined as force per unit area. In other words, when atmospheric pressure at sea level is rated at 14.7 psi, there are 14.7 pounds of air weighing down on every square inch of your head and shoulders as you stand looking out over the ocean, contemplating the meaning of life. With this kind of burden to bear, is it any wonder more people prefer to take their towels to the beach and lie down rather than philosophize?

But it wasn't always so. In fact, during the 17th century, a true gentleman's first priority was not the trolling of beaches for ladies working on their tans. It was instead, at least by all indications, the pursuit of a pressurized water system.

For example, Robert Boyle, an English philosopher, chemist, and father of the modern pressure tank, discovered that pressure varies inversely with volume – an observation now known as Boyle's Law. And at about the same time, Blaise Pascal, noted French mathematician, physicist, and part-time plumber, observed that the pressure applied to a fluid at rest is transmitted equally in all directions.

Now flash forward to the present-day kitchen sink and things get even more complicated. We have just filled a kettle at the sink, the tap is turned off, but the pump is still running. Why? It's replenishing the pressure tank. A pressure tank is known as a hydropneumatic device, meaning that it involves the combined action of water and air. According to Boyle, as water is pumped into the tank, any air held in the tank will compress, increasing in pressure as it decreases in volume. When the pressure reaches a predetermined level (usually 40–50 psi), a pressure-sensitive switch turns off the pump. The entire system

is now fully pressurized, waiting for our next demand for water.

This is where Pascal's observations come in. The water sitting in those pressure lines is attempting, with equal force, to break out of every square inch of pipe, tap, or joint. If there's a leak or weak spot, it will find it. If we turn the tap on, the water will pour out. It has no choice because (back to you, Boyle) it's being pushed out by the compressed air in the pressure tank. And as the water flows out of the tap, draining out of the pressure tank in the process, the air inside the tank expands, decreasing in pressure. When the pressure switch senses that the pressure has reached its predetermined minimum, (usually 20–30 psi), a signal is sent to the pump to start up and begin replenishing the tank.

Why do we need the air? Why not simply compress the water? Because water won't compress, but air does. And because air compresses, its presence in the pressure tank also acts as a shock absorber, reducing the jolt of sudden cut-offs to the plumbing system (such as hastily turning off a tap when that kettle in your hand overflows).

Pascal's perceptions also mean that a pipe stamped with a specific pressure rating, such as 100 psi, is designed to tolerate a force equal to that rating, being exerted from within, over every square inch of its interior surface. To get a CSA, NSF, or similar approval, the pipe must be able to tolerate a force equal to three times its given rating – in other words, a 100 psi rated pipe has to tolerate 300 psi. At least when new. But time and abuse from nature and humanity take their toll. As the pipe weakens, its designated pressure rating drops, which is just one reason to opt for 100 psi or greater pipe.

ally fail. It's called entropy, and sadly nothing, not even you or me, is immune to the effects of this natural process. (That said, PB shouldn't be exposed to direct sunlight, water temperature in excess of 180° F (82° C), or water with over 2 ppm of free chlorine.)

The good news for DIY plumbers is that PB has been replaced with PEX (a cross-linked high-density polyethylene). PEX will withstand higher temperatures than PB, higher concentrations of chlorine, and doesn't exhibit as much longitudinal stretch and contraction, a.k.a. "creep". The walls of PEX pipes are about 22% thicker than PB pipe, yet despite this it still bends almost as

well as a vacuum cleaner hose, the minimum allowable radius of the curve being approximately 10 times the pipe's diameter. In other words, a ½" PEX pipe could be curved around a 5" (13 cm) radius. This allows you to make long swooping curves from one point to another with no joints or fittings required, cutting down on both the workload and the installed cost. And, bonus, the price of PEX pipe runs about 25% less than copper. To join sections of PEX pipe, a brass or copper insert fitting is used, typically held in place by a crimped compression ring. Elbows, Ts, and such slip into the ends of the pipe and are then crimped in place with a special crimp-

ing tool (the trade versions can often be rented at the plumbing supply outlet where you purchased the pipe, but a few acceptable economical home versions are also available). Again, no muss, no fuss, and not much expense. The trick to leak-free joints is the compression ring: crimp it too tight and it can crack the fitting; crimp it too little and water will find a way to sneak past. There are simple sizing gauges you can buy to assess the crimp, but with or without this tool always test the system before covering it up behind walls.

For those harbouring misgivings about crimped fittings (thanks, perhaps, to misguided sensationalist news stories and overenthusiastic tradespeople), O-ring compression fittings are also available. Regardless of fittings, PEX pipe will sag, more even than my stomach, so it demands more frequent support than rigid pipe, such as CVPC or copper. Run PEX pipe through plastic clamps or framing members about every 30" (75 cm).

The final caution with PEX is that the wall thickness of the pipe varies between manufacturers, so the fittings are not universal. And often the manufacturer is not easy to identify. The simple solution is to buy all the fittings from the place you bought the pipe. Some PEX brands become brittle when exposed to sunlight and therefore must be installed (and stored) out of the sun's direct rays. On the good news front, most PEX tends to resist damage from an occasional freezing, the pipe expanding slightly to accommodate the expanding ice forming inside, then contracting as the ice thaws. But no pipe is immune from freeze damage, particularly after repeated freeze-thaw cycles.

Under normal use, all variations of plastic pipe tend to corrode less than metal alternatives, leaching less into the water while remaining unobstructed from build-up of internal scale. Any plastic pipe must be protected from heat sources, such as furnace ducts and recessed lighting, and from possible punctures, such as those caused by driving nails into the wall to hang a picture of you proudly turning on a tap as a record of your lasting plumbing prowess.

LAYING OUT THE PRESSURE LINES

No matter what plumbing materials you use, the entire pressurized system should follow a gradual slope to a central drain point or, if this isn't possible, to a couple of points. The reason for the slant is to facilitate easy draining of the system for service or updates, or for seasonal parking of the plumbing. Use the same 1/4" per foot of horizontal run (2 cm per metre) minimum as suggested for the intake line.

The best place for the system drain tap is at its lowest point, which is often found next to the pump or pressure tank. To drain the system, just connect a hose to the tap and let it run outside. If your water system doesn't have a drain tap at its lowest point, install one.

A PRESSURE TANK'S PURPOSE

Pressure lines create a distribution system that provides water on demand. We open a tap, and water pours out. What sorcery is at the root of this? A pump could do it, but it would be called into duty every time we asked for water (much as the traditional hand pump is). Gravity could be another answer. If the water source or storage container is higher than the tap, the water will flow out every time the tap is opened. For example, a well or spring at the top of a hill can provide sufficient pressure to keep an indoor system full of water, ready to pour out. So too can a water tower, which is why they are used by many municipalities to maintain water pressure. My in-laws' first cottage made use of one too, though obviously on a much smaller scale.

Unfortunately, a well or spring is seldom conveniently located on a hill out back. And water towers can be expensive to construct. (Because the pressure is controlled by volume and height, you need a large container propped up high in the air if you're a fan of the high-pressure shower.) A tower is also susceptible to freezing and general wear and tear from the weather and, if they're open on top, to whatever's floating around in the air, such as acid rain or bird drop-

pings. And you still require a pump to lift the water up to the tower in the first place. If power is available to operate a pump, and the added storage a tower might provide is not needed, then it's tough to beat the pressure tank for convenience.

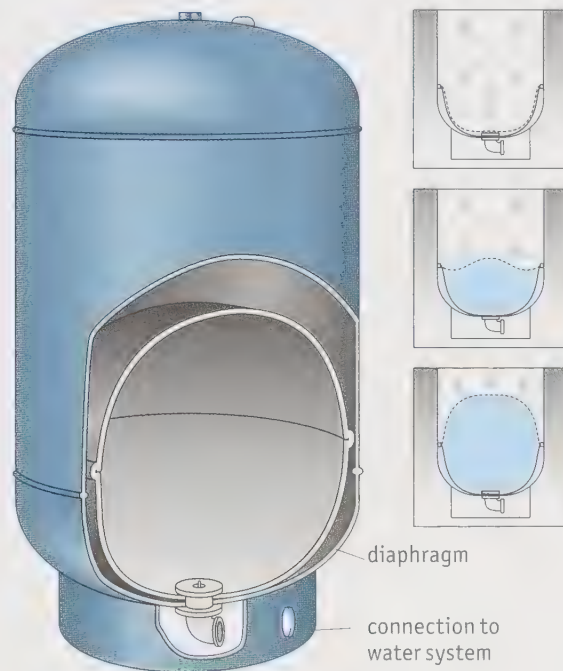
The pressure tank serves a dual function in any water system: It provides a modicum of storage so that the pump does not have to operate every time water is demanded and it maintains pressure throughout the system when the pump is not operating. (See *Pressure Tactics*, p. 61.) The amount of water that can be drained from a tank before the pressure switch asks the pump to start up again is known as its drawdown, or sometimes draw-off (more on this later). Ideally, the drawdown should not empty the tank, but keep a small reserve for power outages. The correct size of tank is determined by family needs, pump capabilities, the size and length of the intake line, and water source yield. While a bigger tank might better suit the water-greedy among us, if it's fed by a slow- or low-yield well, a smaller tank would be less likely to drain the well, allowing the well to replenish itself between pumping cycles. It's a site-specific thing: Talk to your local plumbing supplier about what size best suits your requirements.

There are two basic types of pressure tanks: air injection and the now-ubiquitous bladder or diaphragm tank. With the air injection tank, air and water share the same space, and are in direct contact with each other. Water, being an almost-universal solvent, absorbs air molecules, a process that increases in direct proportion to increases in pressure. Slowly, as the water absorbs more and more air, the amount of air available to compress diminishes, decreasing the drawdown. (To find out why, see *Pressure Tactics*, p.61.) The smaller the drawdown, the more often the pump cycles, a situation usually well documented in your electric bill. Not so visible is the added wear on the pump. When a tank's drawdown is reduced in this manner, the tank is referred to as being "waterlogged".

To combat this phenomenon, a floating disc was sometimes inserted between the water and air to discourage their incessant mingling.

This disc works about as well as a drunk chaperon at a teen dance. A better method is to simply acknowledge the problem and keep adding air. This can be done through a Shrader valve (the same sort of valve used to pump up your vehicle's tires), mounted on the top or side of the tank, or on the T-pipe entering the tank. The tank's owner (you) pumps in more air whenever the pump is heard to be cycling too frequently. Better still is the air-volume control, or air-charger, which automatically injects air into the tank as needed each time the pump turns on.

DIAPHRAGM TANK



Contents under pressure:

1. Tank empty; pump starts up and begins to fill diaphragm.
2. As diaphragm fills, the air above it is compressed.
3. When air is compressed to an amount determined by the pressure switch, the pump shuts off, leaving the diaphragm full of water under pressure, ready to pour out the faucet.

Traditionally, these tanks are made of galvanized steel and feature a charger, a bulged 3" (7.6 cm) diameter disc, that clings to a tank's side like a wart, with a small diameter copper or plastic tube running between it and the pump. A neat little valve known as a snifter is drawn open or shut by pressure differentials between the water adjacent to the valve and the surrounding air. These differentials are at their extremes when the pump starts or stops. When the snifter opens, the control sucks in a wee blast of air. When the

shifter valve closes, the water pressure in the line pushes the air into the tank. Unfortunately, neither these air-control valves or galvanized tanks have a good reliability record, rust usually being the main problem. However, there's a newer, and much better, version of the air injection tank, the fibreglass composite tank with a plastic air-control valve, which eliminates the problem of rust and the potential for lead from the galvanizing to leach into your water.

A bladder or diaphragm tank doesn't inject air into the water, but instead gives the air its own compartment. The water is contained within a flexible sealed bag (or bladder), or behind a flexible membrane (or diaphragm) bonded to the inside of the tank. The bladder type is slightly more efficient, but in either case, the air and water don't mix so there's no loss of drawdown. As a result, no air-volume control is needed.

Bladder and diaphragm tanks are more expensive than traditional air-injection galvanized tanks, which explains why galvanized tanks are still on the market. Pressure tanks, whether air-injection or diaphragm-style, are often packaged with a top-mounted jet pump, making for a compact combination that's well-suited to the often-cramped quarters of cottage and rural crawlspaces or pump houses.

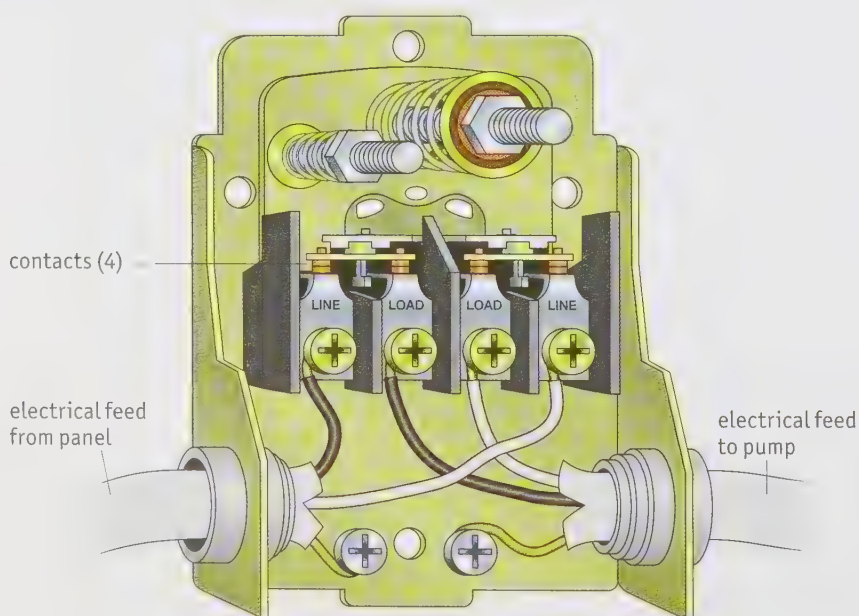
Pressure management: Usually housed in a small, grey box, the pressure switch senses changes in the system and opens or closes a set of contacts to turn the pump on or off. If these contacts corrode, they can stick in the closed position, commanding the pump to run constantly. Fortunately, a simple fix can be managed with a business card or a fingernail file.

THE PRESSURE SWITCH: HOW TO KEEP IT SWITCHING

Attached to a terrestrial pump, pressure tank, or the line between the pump and tank, is a small rectangular box about 2½" x 2½" x 3" (6 cm x 6 cm x 9 cm). Often, it's grey with a squared "D" embossed on the top. This is the pressure switch. A flexible diaphragm inside senses pressure changes in the system, opening or closing a set of contact points to turn the pump off or on in response to those changes. The switch is preset at the factory to maintain pressure between 20–40 psi, or 30–50 psi.

Over time, the contacts in the switch can become corroded and pitted, particularly if the switch is situated in a damp area (such as the aforementioned crawlspace or pump house), causing the points to stick and the pump to remain on. As a quick fix, with the power to the pump and switch turned off, remove the small nut on top of the switch cover to expose the inner workings. The four contact points are easily identified. Force them open with your hand or a small screwdriver, then carefully clean the contacts with clean, white paper (such as the plumber's business card) or, if badly corroded, with a metal (not emery) fingernail file. Blow the filings

PRESSURE SWITCH



TROUBLESHOOTING GUIDE

PROBLEM CAUSE AND SOLUTION

PUMP FAILS TO REPRIME AFTER INITIAL PRIME

Initial prime was inadequate (remove priming plug and look for water): Repeat the priming procedure. (See Chapter 12: Max's Amazing Easy Prime precludes the possibility of this problem.)

Mechanical seal leaks: Replace the seal.

Air leak in intake line: Check for cracks in the pipe and for loose clamps and leaking joints.

Strainer clogged: Clean.

Foot valve is defective: Clean or replace as necessary.

Suction head too great: Place the pump closer to the water source.

Piston pump pooped: Should the motor run yet no water spew forth and all the above faults have been discounted, the piston leathers, valves or valve seats could be worn. Consult the owner's manual and your toolbox, or the TV listings and a plumber. Also, check belt tension. If you are lucky, the simple tightening of a loose belt may be all that is needed. Again, consult the manual for correct amount of tension.

Control valve on deep-well jet not adjusted correctly: Check manual and adjust valve for sufficient back pressure to operate remote injector.

Water leak on inner pipe injector (packer jet): Leak can be between packer assembly and well casing or between defective well casing and surrounding soil (more likely on an older drilled well). Call a plumber.

CAN'T FIND PUMP MANUAL

It's lost: Look again. If at the cottage, check the house back at the city. Order a new one. Look for a PDF version on the internet. Whatever type of pump you have, the manual is a must.

REDUCED DISCHARGE RATE OR NO DELIVERY

Strainer clogged: Clean.

Foot valve is defective: Clean or replace as necessary.

Air leak in intake line: Check for cracks in the pipe and for loose clamps and leaking joints.

Incorrect pipe size: Change pipe for appropriate diameter. If your system employs any steel piping, it could be corroded, thereby restricting flow. This might be an opportune time to switch over to plastic pipe.

Ancient plastic pipe has too many (possibly leaky) joints: Replace with single run of new pipe

Impeller is excessively worn: Replace the impeller.

Leather worn on piston pump: Replace the leather.

Valves not seating properly on piston pump: Clean or replace.

Suction or discharge head is too high: Change pump position to correct. If total head is too high, or you're unable to reduce combination of suction head and head loss, a deep-well or submersible pump may be required.

Debris is lodged in the impeller: Clean out the impeller.

Pipes are frozen: Thaw pipes (see Chapter 11).

Continued on next page

TROUBLESHOOTING GUIDE (continued)

PROBLEM

CAUSE AND SOLUTION

**PUMP
DISCHARGES
SMALL
AMOUNT OF
WATER, THEN
FAILS**

Air is trapped in the pump or line: Reprime. Reroute pipe to remove air pockets in low spots.
Suction head is too great: Place the pump closer to the water source.
Intake line is too long or the diameter of pipe too small: Place the pump closer to the water source and/or increase pipe size.

**PUMP
DISCHARGES
FULL STREAM,
THEN FAILS**

Obstruction in strainer, foot valve, intake line, or impeller: Check and clean.
Air leak in intake line: Repair.
Ancient plastic pipe has too many (possibly leaky) joints: Replace with single run of new pipe.
Water level is dropping below the intake. This can happen with low-yield wells or, if dealing with surface water, during heavy wave action or if the water level drops substantially during course of season: Lower the intake (foot valve).

**PUMP MOTOR
DOES NOT RUN**

Switch is not on: Turn on the switch, then fabricate an appropriate and confused technical excuse for the pump's failure so as to avoid potential ridicule from friends and family.
Fuse blown or breaker tripped: Replace the fuse or reset breaker. If it happens again, call an electrician. (They are usually cheaper than a plumber.) The overload protector on a three-wire submersible can sometimes trip if the control box becomes hot to the touch from exposure to some external heat source, like direct sunlight. Make a sun-shade for the box (a small roof does the trick) or move the box away from the heat source. Overload protectors on jet and piston pump motors can also trip if the motor overheats, the most probable cause being insufficient ventilation. Give it some air.
Loose or disconnected wires at the motor: Turn the power off at the main panel and reconnect the loose wires.
Pressure switch contacts are dirty: Turn the power off, remove the pressure switch cover, and clean the contacts with clean white paper, very fine emery cloth, or if badly corroded, a fingernail file.
Impeller is jammed (called a "bound pump" on a submersible): Clean out the impeller and eliminate any source of debris. Always run a new pump until the water clears, so as not to leave any initial sludge sitting in the impeller(s).
Stuffing box on piston pump adjusted too tight: Now don't you wish you could tell your friends you had a problem like that? Slacken the adjusting nut.
Defective motor: Trade wallet for new motor or pump.

**PUMP DON'T
WORK 'CAUSE
THE VANDALS
TOOK THE
HANDLES**

Problem first documented in 1965 by noted musician/occasional-plumber Bob Dylan:
Buy a new handle and get over it.

TROUBLESHOOTING GUIDE (*continued*)

PROBLEM	CAUSE AND SOLUTION
PUMP DOES NOT SHUT OFF	Pressure switch contacts are stuck in the "on" position: Turn the power off, remove the pressure switch cover, and clean the contacts with clean white paper, very fine emery cloth, or if badly corroded, a fingernail file. Replace pump switch, if necessary. Taps left on or toilet running: Turn the tap off, or fiddle with the levers and chains inside the toilet tank until it seals properly. (If this problem reoccurs, you will need to replace the offending bits in the tank.) Foot valve, strainer, or submersible pump screen blocked: Clean and check for source of debris. Relocation of the strainer, etc, may be necessary to achieve sufficient clearance from the bottom of the water source. Check valve stuck closed: Clean or replace. Major leak in plumbing or pipes: Issue rain coats and rubber boots and repair leak. Suction head dropped below end of intake line or allowable lift (a maximum of 25 ft. at sea level, for example): Lower intake line in water source, move pump closer to source, restrict pump capacity to match low yield (e.g. install tail pipe on deep-well jet pump, larger pulley on piston pump motor), purchase smaller pump. Pump worn: Replace leathers on piston pump; impeller on centrifugal, jet or submersible; or replace pump. Pump shaft broken on submersible or coupling joining motor and pump loose: Replace defective parts or entire pump (whichever depletes the wish fund the least). Control box on submersible pump is defective: Call a plumber or replace the box.
PUMP RUNS FREQUENTLY WHEN NO APPARENT DEMAND FOR WATER (<i>motor will be excessively hot</i>)	See possible causes under "Pump Does Not Shut Off". Pressure tank waterlogged: See tank manual for correct procedure on checking air volume control or snifter valve. Clean or replace control or valve, and drain and recharge tank. If tank is really old, replace with newer diaphragm-style model.
EXCESS PUMP NOISE	Pump moving on mounts: Secure pump in place on adequate footings. Motor bearings worn: Replace bearings or motor. Water level low (air getting into line): Lower intake line (may require moving pump closer to source). Foot valve or strainer partially obstructed: Clean. Intake line too restrictive: Move pump closer to source and/or install larger diameter pipe. Low oil level in piston pump crankcase: Top up with appropriate grade of oil. (See manual.) Piston pump pulleys loose: Turn power off and tighten set screws on pulleys. Piston pump belt too loose or too tight: Turn power off and adjust belt.
EVERYTHING SEEMS TO WORK FINE	Something must be wrong: Relax and you're done for. What was that noise? Better check the pump. No, maybe it's the foot valve. Better lie down and listen for the foot valve. This could take time.

away (the contacts will close by themselves), put the cover back on, and turn on the electricity. If the pump still misbehaves, the switch may need replacing. (Don't throw away that business card yet.) Even if the pump works, the fix is only temporary as, once worn, the contacts will corrode again soon. Time for a new pressure switch.

GETTING INTO HOT WATER

Hot water is one of life's luxuries you can do without, but isn't it nice to be able to have a hot bath at the end of a damp, cool day? The problem is, hot water tanks are expensive to operate; they're often the single-greatest consumer of domestic electricity or gas. One solution (and the one I opted for) is the so-called space-saver hot-water tank. These are small tanks, ranging from 7–30 US gal (25–115 L), the larger of which can handle most family needs (as long as those needs don't include such heavy hot-water users as dishwashers, clothes washers, and whirlpool tubs). And for cottagers in particular, these tanks offer a few important advantages: They fit into small places, such as under the kitchen counter, and because there's less water to heat, recovery time is faster and operating costs are lower. As a bonus, most of the small tanks are available in 115V format, making wiring a less-intimidating experience.

Tankless on-demand hot-water heaters are becoming increasingly common, and with that, a bit less expensive to purchase. Still, as of this writing, expect to pay about three times the price of a comparable gas or electrical hot-water tank. (Tankless and conventional heaters can often also be rented through local utility companies). Tankless heaters take up very little space and, because they only heat the water as you need it, use less electricity or gas than conventional storage-type tanks. When first introduced, individual heaters were often required for every hot-water outlet, but whole-house units are now available, reducing initial expense. Whole-house or not, some units still suffer from modest flow rates.

Since the sun has been warming water for millennia, it seems to make sense to use it to heat your household water. But initial expense, and maintenance, are the downfalls of most active solar systems – perhaps justifiable in high-demand situations but tough to rationalize for those of modest hot-water needs or for occasional-use cottages. (Note: Active solar systems need sunshine and mechanical pumps and heat exchangers to work; passive solar systems only require sunshine, relying on the way liquids and gases move as they change temperature to finish the job.) For folks with very limited hot-water demands, or no access to electricity or gas, there are passive-solar hot-water heaters available that take advantage of a principle known as thermosiphon. A series of connected tubes sits on the roof of the building, facing south. As the water is warmed by the sun, it rises within the tubes, drawing up colder water from a storage tank, this incoming water forcing the hotter water down to that same tank. The water keeps circulating, gathering heat until a tap is opened. Or at least it does as long as the sun is out. The system produces limited quantities of warm water and is subject to freezing if left full during cold spells, but it's simple and cheap, and well within the grasp of an industrious do-it-yourselfer.

THE WASTE SYSTEM

This is where the used and unwanted water gets drained out of the building. The road to effective drainage is all downhill: $\frac{3}{8}$ "– $\frac{1}{4}$ " per foot of horizontal run, or a 1–2 cm drop per metre, to be exact. Surprisingly, increasing the slope of waste pipes does not reward you with better drainage, it actually hinders the flow. It has to do with the dynamics of dung, which needs a certain amount of water in order to move through the pipes. Steeper slopes let the liquids run out but leave the solids hanging. Of course, there are times when architecture or topography dictates that the line must drop at a greater angle, in which case it should be set at no less than 45° – steep enough to encourage everything to drain.

As with the supply system, plastic is the material of choice for waste lines, usually ABS for the inside and PVC for the lines outside leading to the septic tank. (Check with local authorities for what's approved for your area.) Main waste lines are usually 4" in diameter, while secondary feed lines (from sinks and tubs, for instance) and vent stacks can range from 1½"–4". To aid draining and provide odours with an easy exit to the great outdoors, vent pipes for every fixture are essential. Often, these vents are connected to the central stack that vents the main sewage line.

The methods of treating wastes are varied, and in some cases very site-specific. Considering the importance of doing it right, it may come as no surprise that four chapters (Chapters 7–10) are dedicated to the discussion of dung and grey water disposal.

What's in the water?

Waterborne pathogens

Algae and cyanobacteria

Minerals and chemical compounds

Hard, soft, acid, or alkaline?

Nutrient enrichment

Getting a water report

5. CHECKING YOUR WATER QUALITY

What could be lurking in your lake, river, or well?

MY NEXT GLASS OF WATER might come from our artesian spring, or more likely of late, from our drilled well. Either way, the water is essentially clear. It is also cold, and tastes better than anything that ever poured out of a city tap. It has flavour – we drink it for pleasure, not just to quench thirst. But is it safe to drink?

It must be. I mean, look at the stuff – what nasty substances could possibly lurk in water so transparently pure?

Actually, plenty. H_2O is the consummate capricious companion, a flirtatious molecule that has intimate relations with just about everything it meets. And as our demand for water increases – for drinking, cooking, and washing, for irrigating lawns, gardens, and crops, for livestock and pets, and even to use as a playground and dumping ground – that adventurous molecule's exposure to potential mates also increases dramatically, as does our risk of illness. So the list of ingredients on the side of each glass of water is getting longer, and varies from glass to glass.

But it's not all bad news. We don't want perfectly pure water, because H_2O on its own has no taste. What we want is good tasting, healthy *drinking* water. Deciding what constitutes that, and how to achieve it, is another matter. The problem is that we are dealing with two major variables: humanity and water. Susceptibility to contaminants differs for every individual and for every body (or glass) of water. And even if we were able to eliminate the variables, science is still undecided as to how little of a given substance it takes to harm an individual, a fact reflected in the wide variance in official water-quality standards throughout North America, let alone the rest of the planet.

To put these potential hazards into perspective, the most dangerous aspect of water in the so-called developed world is that people drown in it: Statistically, North Americans are more likely to die from breathing water than from drinking it. With this in mind, let's look at the constituents most likely to pour out of your tap.

MICROORGANISMS

As the name implies, these are microscopic life forms, unseen by the naked eye. Life on this planet would not exist without them, and they outnumber every other form of life by a wide margin. To take a small, isolated sample of the microbial world – you – there are about 10 times as many bacteria cells inside of you than there are body cells, approximately 100 quadrillion in case you were thinking about naming them. And there's about the same number of viruses, plus a few less fungi, which doesn't make it sound like a particularly nice place to live, does it? But, looking into it more carefully, some of those microbes are working hard to keep us functioning, with many more simply trying to look busy and not attract attention, while a lesser number are not nearly so passive or agreeable, with a few of those bent on destroying their place of employment. So it's just like any large organization, really. And, as always, it's that smaller disagreeable group that we need to pay attention to, the disease-causing micro-critters known as pathogens.

Most waterborne pathogenic microbes are between homes, many having recently vacated the intestine of some warm-blooded animal in search of another. Any time faecal material from pets, wild animals, livestock, or humans gets into the water (directly, or via dysfunctional or improperly located public or private sewage systems or from agricultural runoff), you can bet a full case of Pepto that pathogens are probably present. And microbes don't always originate from the source water. Sometimes, via a process known as grow-back, microbes sneak in via the exit, such as a bathroom or kitchen tap, to begin colonizing the tap's aerator, and may even spread deeper into your water system. So who are all these microscopic guys?

BACTERIA

Bacteria are single-celled microorganisms weighing in at about one-trillionth of a gram each. Aside from life itself, without bacteria we also

wouldn't have yoghurt, or vinegar for the fries, or cheese for the burger. On the pathogenic side of things, dysentery is the most likely bacterial ailment to afflict us via the water, typically from *E. coli*, though bacterial boaters are also the cause of cholera and typhoid fever.

PROTOZOA

Protozoa are also single-celled microorganisms, only slightly larger than and one step up the evolutionary ladder from bacteria (the difference having to do with where each parks its DNA). Protozoa have an uncanny ability to become encysted, donning armour plating just before leaving home-sweet-intestine, and losing it again once inside their next host (you, for example). Cysts are the battle tanks of the microorganism army, stubbornly resistant to hostile attacks by disinfectants, such as chlorine or iodine, or cold temperatures. *Giardia*, the courier of giardiasis (better known as beaver fever), is the most prevalent water-borne pathogenic cyst in North America, though *Cryptosporidium* is certainly gaining in popularity. Sometimes, you may not even know you've been infected by *Giardia* or *Cryptosporidium*, perhaps just feeling a little "off", but more likely either of these protozoa will double your annual budget for toilet paper in a matter of weeks, and in some folks – such as children, the elderly, and immunocompromised individuals – infection can lead to serious illness and possibly death.

BEAVERS VICTIM OF BAD PRESS

The beaver gets a bad rap for beaver fever, a.k.a. giardiasis. Yes, this toothy rodent can spread the disease, but so can many other animals, including deer, moose, and *Homo sapiens*. In fact, it's quite probable that the beaver acquired the pathogen by drinking waters contaminated by the faeces of humanity before depositing the bug back into the water. Statistically, you are more likely to contract giardiasis from soiled diapers at a daycare centre than you are from your drinking water. (Even the most diligent of liability lawyers would have a hard time pinning that one on the beaver.)

Of course, this doesn't mean you shouldn't be worried about contracting giardiasis from drinking water, but quit blaming the beaver, eh?

VIRUSES

There's an ongoing debate over whether viruses are really organisms or not, but regardless, for convenience sake viruses are generally considered to be microorganisms. The debate lies in their cellular structure: viruses haven't got one, which by humanity's definition, is necessary for an organism to be an organism. Scientific squabbles aside, viruses are much smaller than bacteria. In fact, if you were a virus, a bacteria standing next to you would seem as large as a thirty-storey apartment building. But what they lack in size, they make up for in devious behaviour, abducting a host cell's DNA or RNA and reprogramming it for their own purposes, such as propagation. The hosts can be other microbes, plants, or animals. In water there are more viruses than all other microbes combined. Although not all viruses are harmful to humans, pathogenic viruses are responsible for many of humanity's diseases, including the water-borne infectious hepatitis A and E., Norwalk, polio, and rotavirus (the most common cause of severe diarrhea in children in the US).

ALGAE

Here's another confusing tiny bit of life. And as always, it's not nature that's confused, but us, having labeled everything that looks like algae as algae. But, to quote those famed microbiologist and part-time composer siblings, the Gershwins, "It ain't necessarily so." Multicellular algae are the legit stuff, the real deal. Algae, in other words. Blue-green algae aren't: They're single-celled bacteria correctly known as cyanobacteria. What confuses us is that cyanobacteria often bunch together en masse and appear much like algae. Blue-green algae are very good at converting atmospheric nitrogen into a usable form for plant life (through a process known as nitrogen fixation). In fact, if it weren't for the presence of cyanobacteria in the fertilizer of Asian rice paddies, about three-quarters of the world's rice production wouldn't happen. And blue-green algae is even touted as a healthy food supplement by some folks. (As of this writing, only products

made using *Spirulina* blue-green algae are considered safe for this purpose.) However, 50%–70% of the algae's various permutations (there are about 50 known species as of 2010) can produce toxins (cyanotoxins) harmful to most life forms that might inadvertently consume it, or even bathe in it, such as fish, livestock, pets, and us. Unfortunately, it's these species of blue-green algae that are increasingly showing up in surface water. No part of the planet is exempt from this invasion, and there's no easy way to tell if the algae in your water is not really algae, but cyanobacteria, nor can we tell when it's going to be toxic or, should it disappear, if it might return.

Cyanobacteria dine on phosphorus and nitrogen, and flourish when levels of these nutrients are high (see p. 78). Using light as an energy source, they can adjust their buoyancy, drifting up or down in the water in search of the richest nutrient pockets. Often, we don't even know the algae's there. But should there be enough of the stuff hanging around, and conditions switch from windy to calm, and the algae are either deprived of sunlight or overdosed in sunlight, they lose the ability to drift about as they please and will sometimes float to the surface and amass. The next morning – surprise! – an algae bloom has magically appeared on the water. Yet the algae, and its toxins, were already there, they just hadn't let you know about it.

Cyanotoxins come in a variety of forms and pose a variety of health risks. Exposure via ingestion (whether by drinking, accidental swallowing when swimming, or by using the water during food preparation) or inhalation (from watering lawns, water skiing, and such) can lead to liver, nerve system, or kidney damage, though certainly cyanotoxin's mischief is not restricted to those ailments. Skin contact through washing and swimming can lead to rashes, blisters, and worse should the body absorb the toxins. And sensitivity levels increase the more frequent and greater the exposure, increasing the risk of getting sick and the intensity of the symptoms.

The toxins are released when the bacteria's cell membrane is broken. Cell death, such as when we consume it, squish it (by passing it

through a water pump, for instance), or try killing it using our usual arsenal of microbial weapons will do the trick, as can the simple process of cell aging (sucks to be old, eh?). And because of its varied nature, and life's varied reactions to it, determining an algae's degree of risk is very difficult, making a health department's job of risk assessment next to impossible.

Now for a bit of good news. So far, cyanobacteria is only making appearances in surface water and a few shallow wells located too close to affected surface water. Also, it's less likely to be found in deep water or constantly turbulent water, such as fast-flowing creeks and rivers. Even if detected, as long as it's sparsely distributed throughout the body of surface water, its presence does not automatically mean it's turned usable water into a health risk. Usually, it's only when the algae gathers together and blooms that we can be pretty certain there's enough nasty stuff in there to harm us. Adding to this microbial mystery, should conditions in the water change (such as temperature), the bacteria may magically vanish as quickly as it appeared. And finally, skin rashes are most likely to occur on body bits trapped beneath bathing suits and wetsuits, where the bacteria and toxins can accumulate. So, to my way of thinking, risk of a rash may be diminished by bathing in the nude.

TESTING THE WATERS

Billions of any of the above microorganisms can be lurking in a single glass of water. And it only takes a very small percentage of this crowd – the pathogenic group – to make you very sick. (It's difficult to quantify how few pathogens are required to make you sick and how sick you may become; to a large extent, it depends on the individual immune system's ability to fight off the pathogens.) So if we can't see them, how do we know if the pathogens are present?

A bacteriological test looks for the presence of bacteria. Sometimes it only looks for coliforms, which are aerobic bacteria (ones needing oxygen to survive) that are, or resemble, a particular bacterial species found in the intestines

of warm-blooded animals. But coliforms – faecal or otherwise – aren't the bad guys. Some help us control our body's water balance and, unless you boil your salads, you're likely downing a bunch of them with each mouthful of fresh veggies. But coliforms are known to occasionally hang around with certain bad guys, pathogens, such as *E. coli*. Most pathogens don't live long out on their own and, relative to coliforms, there aren't very many of them, making them difficult and expensive to detect. So often we take the easy way out and look for the gang of microorganisms those pathogens are likely to hang around with – coliforms. The problem is, sometimes such a test misses the pathogens, or more often, we get a false positive. So increasingly, bacteriological tests are going for the primary culprit, *E. coli*, because if even a single tiny cell of it shows up, it means that the water has recently been exposed to intestinal waste and is not fit to drink.

Should a zero count show up on your bacteriological test, the water is considered to be free of pathogens. This is great news, but please don't con yourself into thinking it's a guarantee of safe drinking water. It's only one sample. Lakes and rivers, the surface water sources from which many cottagers draw their water, are easily contaminated, meaning that test results can vary by the hour and from one spot to the next a few feet away. Which is why it's such a gamble to drink untreated surface water. Some groundwater sources, such as shallow wells and springs, are also susceptible to variances in water quality, though usually to a lesser degree. And it's possible that microorganism activity has been curtailed by some other disagreeable substance in the water.

NONPATHOGENIC, BUT STILL A NUISANCE

Two nuisance microorganisms that aren't associated with coliforms are iron bacteria and manganese bacteria. These bacteria show up only in water containing iron or manganese, getting their energy by oxidizing one or the other mineral. Just as oxidization of the metal on the fam-

ily wheels leads to rust, this same process occurring with water-dissolved iron and manganese causes the water to turn reddish-brown, typically leaving an unsightly gooey stain on plumbing fixtures. It takes only small amounts of either mineral to support those bacteria and then things start to get slimy, sometimes to the point of clogging pumps, plumbing and pipes. Biofouling is the official name for it, though yucky is a much better term. As a bonus from nature, iron and manganese bacteria are often accompanied by sulphate-reducing bacteria which bestow on water the charming fragrance of rotten eggs (though hydrogen sulphide, a corrosive gas emanating from water-borne composting vegetable matter, is the usual culprit for this unpleasant odour). None of these bacteria are a health threat, but they can make using your water a truly unpleasant experience.

TANNINS

Another nuisance contaminant is tannin, also known as tannic acid. Tannin is present throughout the plant world. For instance, it occurs in coffee, tea, many fruits and nuts, and many of the trees we sit under while munching on the previous stuff. Because it resists decomposition, it's a good preservative, one of its better-known uses being the preservation of leather (hence, the leather treatment process known as tanning). This, and its varied structure (due to the variety of vegetation from which it originates) makes it a challenge to remove from drinking water.

Tannin in drinking water is most likely to appear in springs and wells bordering swampy areas or surrounded by coniferous trees. Part of the reason the needles of coniferous trees are slow to decompose is that they contain tannic acid. As this acid secretes into the soil, the tannin leaches into groundwater sources. Like iron and manganese, it discolours the water, stains fixtures, and ruins the aesthetic quality of your favourite hot drinks. Tannin also interferes with the absorption of iron, not a good thing for iron-removal filtration systems (and, when consumed in large quantities, it's also not good for humans).

MINERALS

Because of water's aforementioned propensity for palling around with just about any old molecule, all sorts of minerals can become dissolved in it. Some, like cadmium, lead, and mercury, are extremely toxic and, when passed through the food chain, can accumulate in the body, building up over time (such as in the liver and kidneys). Others are necessary and beneficial to life – in the right quantities. For example, we all need a certain amount of iron to assist in transporting oxygen through our bloodstream. But excess amounts of iron in water can give it a metallic taste, stain plumbing fixtures and the laundry, and clog pipes.

Iron comes in two flavours, soluble (or dissolved) iron and insoluble iron. Given that iron is the most common mineral in the earth's crust, chances are there will be at least a sampling of one type in your water. Either flavour of iron may also be served with, or as, organic iron (when iron joins forces with organic matter, such as tannins or lignins) and iron bacteria. And then let's not forget iron's frequent sidekick, manganese, "the terrible twin" of iron; paired, the two are the stain champions of the world.

HARD VS SOFT WATER

Two minerals, calcium and manganese, determine water's relative hardness. These two minerals dissolve in water in the form of carbonates; the more calcium carbonate and/or manganese carbonate compounds, the harder the water. Hard water can cause scaling or encrustation in pipes, kettles, and water heaters, and worse, it can make hair difficult to untangle after a wash. While excessively hard water can taste nasty, many people prefer the taste of moderately hard water. Soft water is usually nicer to wash in, though extremely soft water can corrode metal pipes and fixtures, inviting those metals into your drinking water. Also, very soft water doesn't play well with soap film on skin, the conflict becoming evident when neither the soap nor the residue of dirt rinse away easily.

Appearances, taste and smell are all good indicators of the presence of minerals in the water, but the only way to know which ones are there for sure – and therefore how to remove them, or even whether they need to be removed – is to have the water tested. (See p. 80.)

ACIDIC VS ALKALINE

There is also an indirect relation between hardness/softness and the alkalinity/acidity of water. Carbonates tend to increase its alkalinity. Since fewer carbonates occur naturally in soft water, its potential to become acidic is increased.

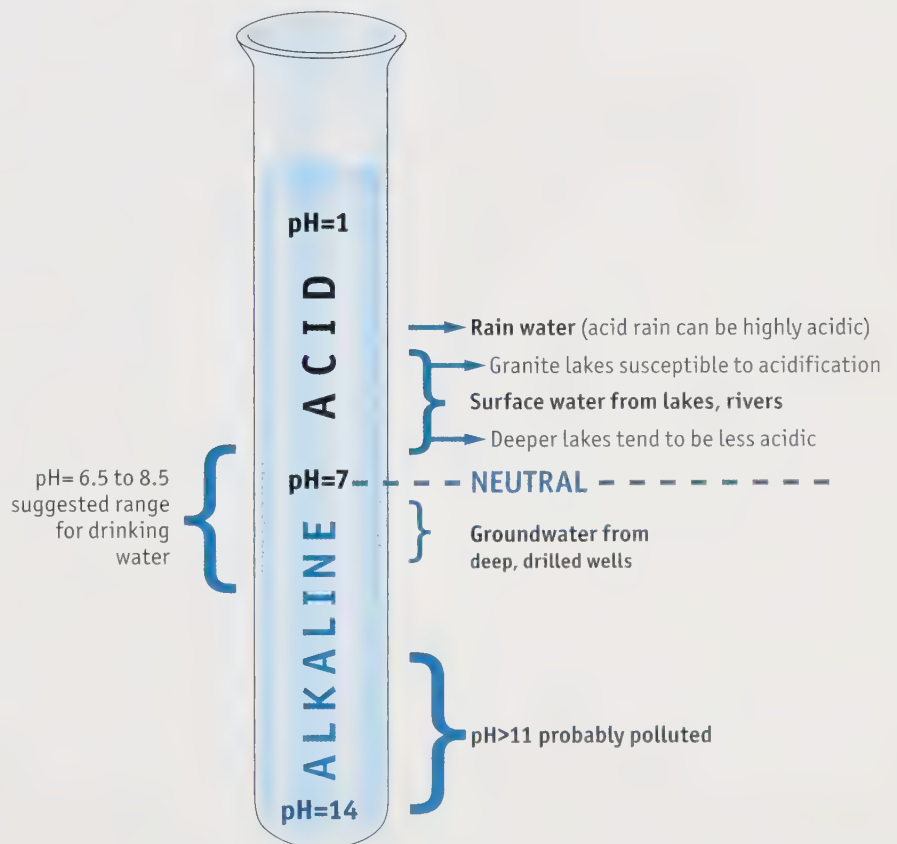
Surface water, and groundwater taken from shallow wells, tends to be slightly acidic to neutral, and also soft; groundwater taken from deep, drilled wells, because of its exposure to various minerals, is usually alkaline and hard. Rainwater is naturally soft and somewhat acidic, but it can become severely acidic depending on the pollutants in the air (hence acid rain), which can in turn affect the acidity of surface water. Deeper lakes, because they have a greater volume of water relative to their surface area than shallow lakes, are less vulnerable to changes from acid rain, taking longer to react and therefore tend to be less acidic. Lakes and rivers that reside in areas of granite, such as those located the Precambrian Shield (Lake Superior, for instance), are more susceptible to acidification. That's because granite doesn't dissolve in the same manner as softer rock, such as limestone, so little of the acid from the air and composting vegetable matter is neutralized.

The relative acidity of water is measured using the pH scale, which tells us how much acid is contained in a water sample relative to the amount of alkali. The scale is numbered from 1 to 14, the difference between each step tenfold (which is why results are often given to the first decimal point, as in 7.3). A pH of 7 is considered neutral (that is, the acidity and the alkalinity are in balance and cancel one another out); below 7, acidic; and above 7, alkaline (also referred to as basic). For instance, the slop sloshing about in our stomach, which has to be very acidic in order to break down all the oddities we drop into

it, has a pH level of around 2. Sometimes, like after a serious late-night pig-out, a stomach's pH will drop even lower. Fortunately for us – checking in at around a pH of 10 – are a number of alkaline antacids we take to counteract the corrosive effects of increased stomach acidity.

The suggested pH range for drinking water is between 6.5 and 8.5. Water that is more acidic can corrode plumbing systems. This is not simply a problem related to system longevity: Significant amounts of lead and copper have been measured in tap water that has spent the night sitting in metal pipes and fixtures. And the older the system, the greater the likelihood of lead being present. Water often sits in the plumbing system of a cottage for much longer periods; if the water is acidic enough to corrode the plumbing, then the potential for higher concentrations of toxic metals in the water is also increased. If concerned, keep the tap running until the water coming out is cold to rid the pipes of standing water.

At the other end of the pH scale, the problem presented by overly alkaline water, as with



hard water, is mostly one of aesthetics and taste, though a pH level of over 11 indicates the water is likely polluted too – usually by caustic effluents released by industry. (Levels that high rarely occur naturally.)

In response to evidence of acid rain affecting water quality, some governments have begun to categorize the lakes within their jurisdictions by the lake's relative sensitivity to acidification. This is a measure of the body of water's potential to become acidic (or more acidic), rather than its actual pH level. To determine the alkalinity level of your water, be it a lake, river, well, or spring, the water must be tested.

PASSING ON THE SALT

Salt (sodium chloride) wins the mineral popularity contest, ending up in more places in greater amounts than any other mineral. (My friend Paul regularly reaffirms the validity of this statement every time he orders a batch of fries.) Too much sodium chloride renders water undrinkable, the salt acting as a dehydrant in the human body. High levels of salt can also aggravate existing health problems, such as hypertension (high blood pressure).

Two potential problem areas are water sources adjacent to busy highways on which large quantities of salt are used to melt snow and ice, and groundwater supplies along coastal regions where sea water seeps into an aquifer as the groundwater table drops (usually after years of extensive depletion due to irrigation). The problem can largely be prevented by locating wells as far as possible from salt sources, and through good well design (see Chapter 2). Keeping road salt out of surface water, such as your lake, means dealing with government bureaucracy, a subject beyond the scope of this book (and reality, for that matter). And sometimes, sodium chloride levels in lakes increase for reasons yet known.

ZEBRA MUSSELS

If you draw your water from a lake or river, these guys and gals could be your intake line's worst

enemy. The zebra mussel is a small ($\frac{1}{4}$ "–2" or 6–50 mm) good-news, bad-news D-shaped mollusc, an extremely prolific one that can quickly populate a freshwater habitat. The good news is that these diminutive critters filter all sorts of gunk out of the water, altering the local habitat. Typically, we see this as clearer water and a noticeable increase in some fish populations. The bad news is other fish populations may diminish. But what we're most likely to notice is how these fecund molluscs tenaciously attach themselves to almost any hard surface, including boats, docks, and even other mussels. And water intakes. They can live out of water for more than a week, and no chemical you would want to add to the water, even if using it to just wash the car, will kill them. Veligers – the teeny-weeny larvae of the mussel – can easily sneak up into a water system, and were once considered to be a serious potential problem. However, the turbulent conditions encountered within the intake system usually prevent the larvae from attaching to any surface – a necessity for the larvae to feed – so the anticipated crisis hasn't really materialized.

CHEMICAL COMPOUNDS

From a chemistry perspective, a compound is formed when one molecule partners with another (or several) to form a new molecule (such as when hydrogen molecules bond with an oxygen molecule to form a water molecule – H_2O). Chemical mixtures, on the other gloved hand, are when chemicals simply share the same space, but no bonding takes place (like when two single people get invited over to a friend's to meet that special someone "I just know you'll like". At last count (not mine), humanity had concocted – intentionally or otherwise – more than seven million known chemical compounds, with thousands more getting added to the list each year. That's a lot of new molecules, many of which get mixed with our water. VOCs (volatile organic chemicals), PCBs (polychlorinated biphenyls), THMs (trihalomethanes), PAHs (polycyclic aro-

matic hydrocarbons), BPA (bisphenol-A) – it's an alphabet soup of known and suspected carcinogens out there. Add to that dioxins and pesticides, and gee-willikers, it's enough to make you sick just thinking about it, or at least a little confused.

Realistically, is there reason to be concerned about such persistent and potentially lethal substances in your drinking water? The fact is, in the small amounts that might appear in the typical water source, you would probably drown long before you could drink enough to cause any harm. But, notice the words “might”, “typical”, and “probably”.

So how do we know if this stuff might be waiting for us in our next cup of tea? There are indicators because such chemicals are the by-products of certain types of human activities. Industry dumping its wastes upstream from your intake line, for instance, is not a good sign. Extensive agricultural activities bordering a well or a lake's watershed are also a warning flag. If you're at all concerned, have a chemical analysis of the water done.

RADIOACTIVE CONTAMINANTS

Radioactive contaminants, or radionuclides, occur naturally in most parts of the world, thanks to the unstable nature of radioactive elements, such as uranium. As these elements slowly break down in rock, soil, and water, radiation is released into the environment. No living organism can avoid it, and at natural levels the presence of radiation is not considered to be a health risk. But, as with almost everything else in life, when exposure levels exceed our tolerance levels, it becomes a problem.

The three most common radionuclides found in water are radon gas, radium, and uranium. All are more likely to be found in groundwater as they tend to dissipate quickly into the environment once in surface water. Radon gas is the most prevalent, and dangerous, of the group, rated second only to smoking as a cause of lung cancer. Typically, the gas seeps into buildings through foundation walls and drains. But it can also be found in your water, where it does the

SWIMMING: COME ON IN, THE WATER'S FINE

For swimming, the quality of the water in North America is, with the exceptions of a few isolated pockets of pollution, very good. Both the Canadian and U.S. federal governments have adopted different suggested standards, the U.S. opting for 200 faecal coliforms per 100 ml while Canada has gone right for the villain, specifying 200 *E. coli* per 100 ml (though provincial and state governments may establish more stringent criteria).

In most cases, chemical contamination of the water is not a problem for swimmers in North America. Normally, the amount of chemicals absorbed through the skin while swimming isn't considered significant enough to pose a potential hazard for the majority of people. The greatest risk of contamination a swimmer faces is when they're downstream from a chemical plant, pulp mill, or similar industry that uses and expels water into the lake or river, the swimmer's dip happening at the same time a chemical spill or similar accident occurs at the plant. To minimize this risk, swim upstream from such industries.

Water quality in a lake or river will vary. The standards mean that the water is considered safe to swim in (not safe to drink) for the majority of people in the majority of water bodies. Because susceptibility to contamination varies widely in both humans and water, the final say as to whether a beach gets closed or not often falls on the shoulders of local authorities, such as a medical officer of health.

That a beach is closed at one location along the shoreline doesn't necessarily mean the water is considered unfit for swimming in some other area of the lake or river. And, obviously, the opposite also holds true. Generally, the further you get away from the shore, the less contaminated the water. On shallow lakes, for instance, you can reduce your risk of exposure just by entering the water from the end of a dock.

To find out more about the water quality for swimming in your area, contact the local health department or health unit.

most damage when released into the air during washing, showering, and doing the dishes (a good reason to postpone all three until tomorrow).

Radium and uranium usually get into our bodies via food and drink, much of it leaving our bodies en route to the sewage system of our choice (see Chapters 7, 8, and 9). Consuming water containing more radium than current standards recommend will increase your risk of cancer. Drinking (and cooking with) water having excessive levels of uranium can damage your kidneys, not from its radioactivity, but its

chemical properties. Radium and uranium usually travel as a team, though when one is discovered in high levels, the other is typically present at much lower levels.

ARSENIC

Arsenic is another common element giving the earth's crust as its home address, and it, too, likes to travel as the rocks and minerals of its home slowly dissolve in water. Officially, arsenic is classified as a metalloid (a sort-of metal), though we all know it as the poison of choice in most murder mysteries because, dissolved in water, it has no colour, taste, or odour. Which should make it obvious that ingesting arsenic along with your drinks in quantities above established limits is not a good thing, though apparently washing with it doesn't pose a health problem.

NUTRIENTS

A nutrient is any chemical that any organism needs to survive and prosper. So nutrients are obviously a good thing, right? Except when we get too much of a good thing. When it comes to drinking water, this caveat particularly applies to two key elements essential to all forms of life: phosphorus and nitrogen. As key elements, neither multiplies nor dies, but exist in finite quantity. Normally, we only encounter them as compounds, teamed up with a few other chemicals as they travel through the ecological cycle. In the right balance, all is well and life carries on as we think it should. But when that balance gets out of kilter, the amount, nature, and variety of life can change rapidly.

THE PHOSPHORUS PROBLEM

Most fresh-water ecosystems, such as lakes, are phosphorus limited in their natural state, meaning that phosphorus is in relative short supply in that system. Because phosphorus is essential to plant growth, aquatic plant life is therefore lim-

ited. But as phosphorus is introduced into the water – a process being greatly accelerated by faulty sewage systems, phosphate-based soaps, detergents, fertilizers, bad agricultural practices, the destruction of marshes, and the clear-cutting of shorelines – aquatic vegetation flourishes.

Usually, the increase in vegetation is first noticed when you go swimming and those icky plants (generally referred to as weeds) brush against you and you just know they're about to drag you under and strangle you and consume your remains. What we don't notice is the slow death of the lake or river. As the vegetation dies, it sinks to the bottom where bacteria assisting in its decomposition also consume water-dissolved oxygen in the dining process. And as water loses dissolved oxygen, phosphorus' solubility increases rapidly, exacerbating the problem. A body of water is considered dead when there is no longer sufficient amounts of dissolved oxygen to support the aquatic life we generally enjoy – plants and fish included, typically replaced by an explosive growth of algae. This process is known as eutrophication.

By the way, the oxygen depletion of water doesn't lead to a basin of Hs and no Os. The basic water molecule consists of two hydrogen atoms riding piggyback on one oxygen atom, hence H_2O . This molecule doesn't break down into its atomic parts very easily. The oxygen available for fish and other aquatic life is dissolved oxygen, O_2 , a separate molecule from H_2O . Dissolved oxygen is also what's consumed when decomposition takes place in the water. Fortunately, the only thing you need to remember is that excess nutrients in the water may lead to oxygen deficits which lead to a so-called dead lake, or dead zone.

NITROGEN: SAME SOURCES, DIFFERENT EFFECTS

Aside from taste, phosphorus doesn't directly degrade the quality of water for drinking purposes. Nitrogen, however, is another matter. Essential to the development of all proteins, and therefore us, too much or not enough nitrogen can stunt growth in all forms of life. High levels of nitrates

(nitrogen with three attached oxygen molecules – NO_3) have been linked to methemoglobinemia, a disease causing oxygen deficiencies in blood. In infants, who have less blood than adults but similar capacities for nitrates, methemoglobinemia (also known as blue-baby syndrome) can lead to brain disorders. And, unlike phosphorus, nitrates do turn up in ground water and wells, not just surface water. But no matter what the source of water, the many variants of nitrogen usually get there in the same manner as phosphorous does – from human and animal sewage, and excess use of chemical fertilizers.

MEASURING NUTRIENT ENRICHMENT

The degree of nutrient enrichment is determined by measuring the amount of chlorophyll in the water, chlorophyll being the green pigment in algae (and other plants), algae being the byproduct of the introduction of the nutrients phosphorus and nitrogen into the water. Add to this a measurement of total phosphorus and you've got a good reading of the lake's pulse.

Lakes registering the least amount of chlorophyll are clear, cold, and usually deep – good lakes for trout. In the spring when the water can still hover around freezing, dissolved oxygen could theoretically reach its maximum possible concentration of 0.8 US oz per 500 US gallons (12 mg per litre).

At the opposite end of the enrichment scale, high concentrations of algae make the water turbid, discoloured (with a possible spectrum of green, yellow, and red), and odorous. It's no fun to swim in, water skiing can be downright unpleasant, and it's certainly no match for Perrier as a beverage. And it can interfere with any water treatment process. As a lake degenerates to this level, the make-up of aquatic life changes, those species requiring the most dissolved oxygen dying off, their carcasses occasionally ending up on shorelines. For example, in the lakes near my neck of the woods, the first fish species to go are lake trout, (assuming the lake was deep and cold enough to support them in the first place), then

the perch and pickerel, to be replaced by catfish and sunfish. And regardless of species, fish harvests are invariably reduced.

Nutrient enrichment does more than lead to a premature death of the lake. Every time we either permit excess nutrients to flow into the watershed (through use of phosphate-based cleaners or by ignoring septic system problems, for example) or make it easier for nutrients to flow into the watershed (by clear-cutting forests and shorelines, for instance), a portion of those nutrients are no longer accessible for use by land-based vegetation. This short-changes those plants, which in turn short-changes animal life (such as us).

There is also an indirect link between nutrient enrichment and other contaminants, such as pathogens and chemicals, the group often arriving via the same bus – sewage and fertilizers being the most obvious examples. Because they feed on nutrients, microorganisms tend to flourish when their levels are high. (A fact we use to our advantage to break down sewage in the septic tank. And in us, for that matter.)

Aside from maintaining and monitoring the effectiveness of your chosen sewage system (see Chapter 7), one of the best things a landowner can do to reduce nutrient overload is to plant trees and shrubs, rather than cut them down, and to encourage wetlands (one of the best nutrient shock-absorbers), rather than fill them in.

TURBIDITY

Turbidity is the cloudiness of the water typically caused by suspended solids such as sediment or algae. It is often a byproduct of nutrient enrichment because as eutrophication increases, there tends to be more stuff in the water. On the other hand, turbidity also signals the potential for nutrient enrichment because as sediment is washed into the lake, nutrients tend to tag along.

Regardless, turbid water can have all the visual appeal of diarrhea, and sometimes taste as bad as it looks. But beyond aesthetic concerns, turbid water can also signal the presence of other

contaminants. Stowaways such as bacteria, pesticides, and phosphorus cling to the particles in droves. Ironically, turbid water is more difficult to disinfect. The particles absorb disinfectants such as chlorine and iodine, and can partially shield bacteria from the radiation of ultraviolet purifiers, diminishing the effectiveness of such pathogen terminators. Abrasive particles like sand can also destroy the seals on pumps and wreak havoc throughout the plumbing system.

Although some water problems, such as turbidity or high levels of minerals, can be detected by our senses, most of water's travelling companions cannot. The only accurate way to determine what's in it is to have it tested.

A REPORT CARD FOR WATER

A bacteriological test, as outlined on p. 73, is usually available free of charge or for a nominal cost from local, provincial or state health departments. For year-round residents, the test should be done quarterly; for seasonal residents, once in the spring and again once the water warms up will probably suffice. (Around the middle of July is good.) But such a test only reveals the water's potential for harbouring a pathogenic populace at the time of the test, nothing more.

To find out what other evils, if any, lurk in your drinking water, you need a thorough chemical analysis of your drinking water, which should test for and report on about 100 different variables. The price of such a test varies greatly from lab to lab, so shop around (but be wary of internet-only based labs). For radon gas, test the air in the house first as that's where the primary danger is. If it's high, you'll need to address that problem (solutions beyond the scope of this book) and also get your water tested. If radon air levels are low, it's extremely unlikely you'll find any in the water.

Although pollutants can travel very long distances, if you have no reason to suspect agricultural or industrial contamination, a less extensive (and less expensive) examination looking for such things as hardness, acidity, lead, mercury, arsenic, coliforms, nitrates, and solids may

suffice. For instance, my local lab's standard test covers about 20–25 variables specific to our area (a good reason to get it done locally). And if it's surface water you're testing, such as a lake, you may be able to share the expense with neighbouring cottagers. But remember, surface water test results can vary from hour to hour.

DO-IT-YOURSELF TESTS

What about home test kits? In the trade, these are referred to as portable test kits and are available from many water-testing labs and water-treatment companies. For testing chloride (which will give an indication of salt contamination), pH, iron, and hardness, many of these kits work well. However, some contain hazardous materials and must be used with considerable caution. They are not suitable for a youngster's science exhibit at the annual fall fair. The problem with portable test kits for other types of contaminants is sensitivity – will they measure low enough quantities to be of any use? For instance, the minimum allowable amount of lead in North America can vary from 10–50 parts per billion (check with your jurisdiction for local regulations). If the test kit won't accurately recognize and measure the presence of lead to at least the mandated level, it's useless as a drinking-water testing procedure. (Sensitivity levels should be listed on the kit's label.)

Many of the portable test kits that measure metals in the water look only for dissolved metals, whereas the criteria used for drinking-water standards usually asks for total metals, including both dissolved and suspended metals. This makes the kit of questionable worth if you want to know what's in the water. Despite claims to the contrary, most portable bacteriological test kits are designed for testing the water in swimming pools, and the difference between acceptable swimming pool water and acceptable drinking water is huge.

Fortunately, a few effective home test kits have trickled onto the market. Perhaps the easiest of the kits to use, and the one least susceptible to cross-contamination (whereby the sample

QUICK TIP

To prevent contamination of the test sample from grow-back at the tap, before taking the sample, wash your hands, remove any aerator, run the tap for about five minutes. Then follow all instructions included with the sample test kit.

becomes tainted by bacteria from the air or your hands) is the Micro Inspector by DSMI. Testing is a simple process (read the kit's instructions), the Micro Inspector using a reagent (in common with many test kits) that changes colour when exposed to coliforms or *E. coli* (depending on which version of the kit you purchase). In this case, the water sample can vary from a light yellow – about the shade of a fine white wine – to dark yellow – what you might expect from an equally fine urine sample. Perhaps to no one's surprise, the wine end of the spectrum means your water is bacteriologically safe to drink, the urine end means it's not. Home tests for radon gas, both airborne and waterborne, are also available.

For a nifty, no-cost way to determine if there's iron in your water, sterilize a small glass jar (if unsure how to do this, ask the aunt who makes you homemade jam for Christmas), sterilize an ungalvanized nail with something like rubbing alcohol, put the nail in the jar, then fill the jar with water (as always, the sample taken before any filtering or purifying). If the water contains soluble iron, it will initially appear clear but in a day or two the iron will settle to the bottom of the jar in a reddish-brown cloud. For insoluble iron, the water will appear rusty, red, or yellow right from the tap. Organic iron looks like weak tea. If iron bacteria is present, the nail will slowly begin to grow what looks like brown fur as the bacteria feed off the iron in the nail. Iron bacteria may also make an appearance on toilet tank walls as a gooey slime.

To test for hardness, wash your hands and hair. Soap and shampoo lather up readily in soft water, less so in hard water. Very soft water will leave a slippery film of soap on the skin.

Tests offered for free or at a nominal cost by water-treatment retailers and distributors can be suspect because of the unavoidable biases inherent in selling a product that purports to correct a problem that their test just might reveal. Some such tests are legit, but some are deliberately misleading. If in doubt, spend the bucks and get it done at a reputable independent laboratory.

Don't let a failed legitimate water report card get you down. There's bound to be some

undesirable stuff in there if somebody looks hard enough. What we want is water that is safe to drink, and that is usually an attainable goal. Remember that as the universal solvent, water might be keen to pal around with all sorts of earthly substances, but it can usually be coaxed into parting with them too.

Types of treatment systems:

Boiling

Distillation

Filtration

UV treatment

Reverse osmosis

Chemical disinfection

How they work and what they remove

Minimum requirements

Combination systems

Non-electric options

Troubleshooting guide

6. PURIFYING THE WATER

Helping your H₂O get a clean bill of health

WATER IS LIKE A WORLD traveller who embarks on a trip having packed only the necessities, then picks up all sorts of stuff along the way. At each new border crossing, some over-worked customs officer must check out this traveller's ever-expanding load of baggage. The officer must know what to look for, how to find hidden contraband, and what to do should any be found. For those of us with private water systems, we are that customs officer. Do we simply let the water pass on through? Or do we order a thorough inspection (as in a water test), and then decide what, if any, items to bar from entry into our house or cottage?

The water pouring from your tap has already been more places than you want to know about, and picked up an incredible cache of souvenirs to show for its travels (see Chapter 5 for a rundown on what to expect), a testimony in part to humanity's unwillingness to control water quality in the public domain. Fortunately, as operators of private water systems, we often have

the option of setting our own standards for what constitutes acceptable drinking water.

Just as countries have standards for what is permissible to import at their borders, most jurisdictions in North America have standards for water quality. A test of your water source will reveal to what extent your drinking water varies from those standards. What to do about any variances is largely up to you. For contaminants that we choose to restrict, we need a water-treatment device or system – some way to remove the contraband from water's baggage.

With few exceptions, the water-treatment industry is a loosely regulated one. And there is little consensus among legislators as to what works and what doesn't. For instance, some government agencies suggest that boiling is not an adequate means to kill bacteria and that only chlorination will work, while others take the opposite point of view. And it's a marvel how this regulatory freedom and jurisdictional confusion feeds the inventive spirit of copywriters for

water-treatment brochures and advertisements. While it's human nature to believe – particularly when believing might save us a few bucks – if a water-treatment device or system seems too good to be true, odds are it probably is. Should an EPA, CSA, or similar logo appear on a water-treatment device, these well-recognized stamps may not reflect on the device's ability to treat water. Often, they are for registration purposes or to show that the device has been approved for use in a plumbing system – not a verification of that product's performance.

Covering all the treatment gizmos and combinations thereof on the market would turn this chapter into a 24-volume water-purification encyclopaedia, so only the most feasible alternatives for single family dwellings and cottage use will be dealt with here. The information is gathered from a great variety of sources, from microbiologists specializing in water purification to, at the other end of the scale, those aforementioned brochures. As mentioned in Chapter 5, the science of water is not exact, so definitive answers are not always available.

POINT-OF-ENTRY OR POINT-OF-USE?

There are a few umbrella categories into which all water-treatment systems can be assigned, two of the more obvious ones being point-of-entry (POE) and point-of-use (POU). Point-of-entry systems treat all the water as it enters the building. This means that all the water is then safe to drink, including the water used to wash dirty dishes or flush the toilet, which will no doubt please the family dog. Such systems can be pricey to purchase, and often require a reliable electrical feed (often not the norm in rural settings), and proprietary replacement parts and factory-authorized maintenance (neither being inexpensive).

Point-of-use systems treat only the water required for consumption, the treatment process now reduced to supplying a single dedicated drinking-water tap since other water outlets, such as faucets and toilets, don't require potable

water. Point-of-use systems are typically less expensive to own and operate than point-of-entry systems, and can usually be installed and maintained by even ham-fisted do-it-yourselfers. Also, less treated water sitting in pipes means a lower chance of re-contamination from opportunistic pathogens that have been “born again” when the system was left unused for a while. With a point-of-use system, any water left in the pipes can easily be flushed out by running the tap for a few minutes. The downside, when compared to a point-of-entry system, is that both family and guests must understand that only the water delivered from the dedicated tap (or taps) is considered safe to drink.

As to which is better, point-of-entry or point-of-use, it's a matter of cost, convenience, and the nature of the contaminants. And while it doesn't make sense, from an energy or chemical point of view, to be treating water we're flushing down the toilet, as we'll learn, there are times that you'll need to treat the water simply to get it that far.

Two other important umbrella categories are filters and purifiers. A filter stops contaminants while a purifier kills them. Sometimes, a treatment device can do both.

Regardless of categories or methods, all water treatment systems require periodic maintenance. With most, this is not a difficult process, but if neglected you might as well not spend the money on a treatment system, perhaps investing in additional health care insurance instead.

THE TREATMENT METHODS

Thanks to water's ever-expanding baggage of weird and wacky contaminants, it's extremely unlikely that any single water-treatment method will reliably turn your source water into clean, good-tasting potable water. So expect the typical water-treatment system to incorporate at least one filter, and often several (each targeted at some selected contaminant), and perhaps some sort of purification device. A purifier doesn't stop contaminants from passing like a filter does but instead, kills them.

BOILING

Boiling is an acceptable method of purifying water when pathogens are the only known contaminant and only small quantities of drinking water are needed. Boiling requires planning so that a supply of boiled, and subsequently cooled, water is always on hand, the inconvenience increasing exponentially with the quantity of water required.

Boiling also consumes large amounts of energy while releasing heat and moisture into the air – potentially a real drag on a hot, humid day. But if you already own a stove and a pot, or an electric kettle, start-up costs for this treatment method are nil.

QUICK TIP

An electric kettle uses about half the electricity to boil water as the stove-top alternative and, perhaps somewhat surprisingly, a microwave is an even greedier appliance if heating up more than a cup or two of water, the differences increasing as the quantity of water increases.

HOW LONG DOES IT TAKE?

Boiling the water will kill all the pathogenic microbes likely to spawn and cause illness. One minute of boiling is usually sufficient to snuff out any microorganisms alive and kicking (or whatever the micro-world equivalent of kicking is). What makes biologists nervous, though, is that some microorganisms “encyst”, going into a dormant state. Test the water after the one-minute boil and all appear dead, but the dormant crowd can later “reactivate”. Some conservative sources suggest that if you want to be certain you’ve done them all in, boil for 20 minutes. Yet this is up to four times longer than most government health departments suggest (at least, those willing to actually put a number on it). Being Canadian, and therefore genetically disposed to compromise, I boil for 5 minutes.

Boiling has no residual effect.

Minimum requirements: a pot and a heat source.

DISTILLATION

A distiller is a close relative to the kettle, the main difference being that it is the evaporated liquid we make use of, not the heated liquid left in the pot. The process of distillation is used ex-

tensively in the industrial and scientific realm to isolate solvents from compound liquids. It’s the means by which we refine crude oil into gasoline, how we get whisky, and also the single most effective way to purify the almost-universal solvent, water.

A water distiller heats the incoming water to its evaporation point, then allows the vapour to condense on a cooled surface where it is collected into a reservoir, ready for use. Anything that isn’t killed by the boiling or doesn’t vaporize is left behind – all the dissolved and suspended solids, minerals (both good and bad), arsenic, and the majority of toxic chemicals and disagreeable tastes and odours.

OPERATING COSTS AND DRAWBACKS

Distillers are reasonably expensive both to purchase and operate. The basic models that only the parsimonious would buy start in the mid three-digit range, the price quickly climbing into four digits as we add basic features such as built-in reservoirs with sight gauges, automatic cleaning systems, and a direct connection to the house or cottage pressure lines.

And while brochure-talk of “pennies a day for pure water” sounds right up my impoverished alley, that statement is only true because pennies do indeed form part of dollars. Actual operating costs will depend on your local cost of electricity (which will definitely increase in the years between now and Armageddon) and the quantity of purified water you need.

From an economic standpoint, distilling anything more than drinking and cooking water doesn’t make sense because large-capacity distillers are very costly both to purchase and operate. Therefore, pollutants potentially damaging to the entire household water system, such as iron or iron bacteria, or just irritating, such as the rotten-egg stench of hydrogen sulphide, would have to be removed by separate treatment methods, such as filtration. (Boiling also shares this shortcoming as a water-treatment method.)

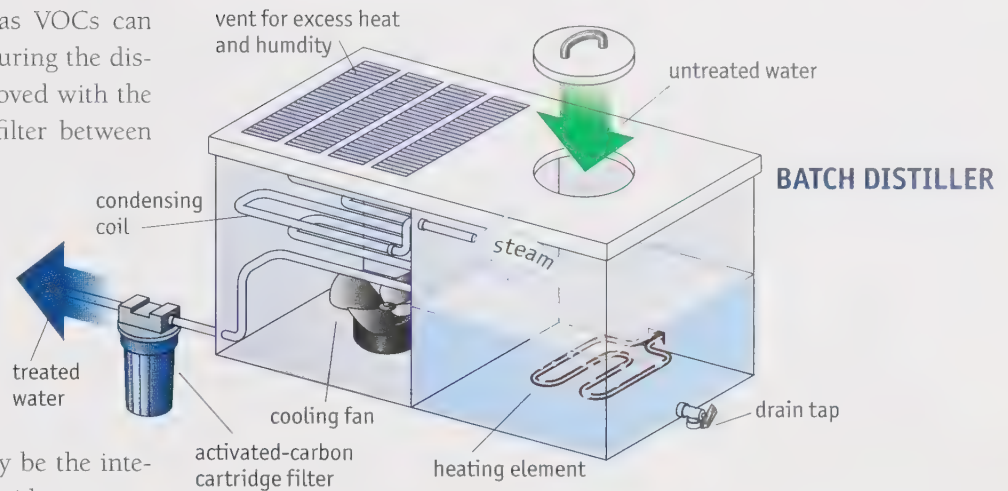
Volatile contaminants such as VOCs can tag along with the water vapour during the distillation process and must be removed with the addition of an activated carbon filter between the condensing surface (often a coiled tube) and the reservoir. Most distillers include such a filter as standard equipment. Others claim to vent a portion of the unwanted volatiles into the atmosphere before the vapour is condensed. As the atmosphere in this case would likely be the interior of your house or cottage, provide a means for these gases to vent outdoors – by opening a window, for instance.

You might want to open a window in any event because, in common with boiling, heat and humidity are by-products of the distillation process. And of course the purified water will need to be cooled before drinking.

Distilled water is essentially mineral free. Critics maintain it will consequently draw minerals out of your body as the water seeks to re-establish its balance of natural components. Advocates cite this same tendency as a benefit, the purified water supposedly “flushing” the body’s system as it toddles on through to the toilet. This latter receptacle seems the best place for either theory. Relative to the quantities your body needs (for instance, about 1,000 mg of calcium per day for adults), the amount of minerals in water just isn’t enough to make a difference to your body (about 3–4 mg in a glass of lake water versus 275 mg in a glass of milk), especially when compared to the indisputable benefits of drinking unpolluted water. Drink and eat right and don’t worry about it.

TYPES OF DISTILLERS

Water distillers fit into one of two broad categories: batch or continuous feed. A batch distiller purifies one batch of water at a time, requiring manual refilling of the boiling chamber as each batch is processed. Continuous-feed models (also known as automatic or direct connection)



are tied into your plumbing system, so the reservoir is automatically topped up as you drain it. Continuous-feed models are more convenient – and more costly – while a batch distiller has the advantage of portability, making it relatively easy to transport between home and cottage. Typical prices start around \$500 for basic batch models, rising about as fast as hot steam from there.

Distillation has no residual effect.

Minimum non-solar requirements: electricity, and a pressurized plumbing system for continuous-feed models.

ULTRAVIOLET RADIATION

Ultraviolet radiation, or UV, purifiers are simple in concept: A water-borne microbe passes by the light and the lamp’s ultraviolet rays rupture its DNA and RNA, disabling the poor dear’s ability to reproduce and subsequently infect. Nothing is added to the water, meaning there’s no residual effect, and nothing is taken away, meaning all the solids, minerals (good and bad), and any toxic chemicals or radioactive substances remain. If your water tests positive for anything other than the presence of microbes, you will have to treat those contaminants separately.

Microbes hiding in or behind turbidity, such as sand or algae, are often shielded from the light’s disinfecting rays, so at the very minimum, all water must pass through a sediment filter be-

Steam cleaner:

Unlike models directly connected to pressurized water lines, batch distillers only purify what you manually pour in – one batch at a time. More work than their automatic cousins, batch distillers are also more portable and more affordable.

fore reaching the UV light chamber (not after, as some systems are marketed). Most manufacturers include one as a matter of course, as well as an activated-carbon filter to remove any nasty tastes, odour, and VOCs, the carbon also located before the UV. (The concern about locating the carbon after UV treatment is that should the UV fail for a moment, such as during an electrical power surge, microbes could sneak through and begin colonizing the carbon filter, obviating the UV's *raison d'être*.)

EXPOSURE TIME

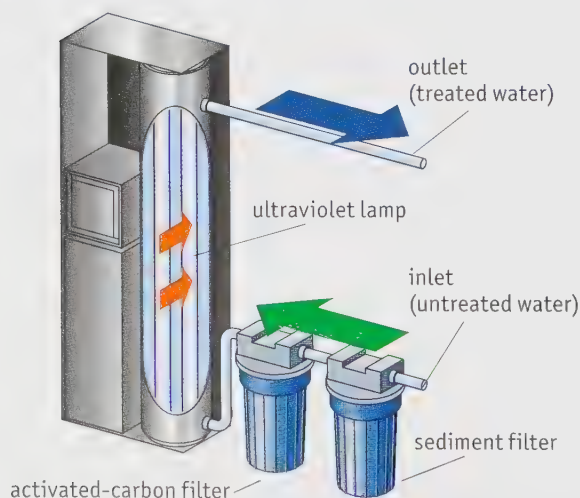
For ultraviolet radiation to work, the pathogens, and hence the water, must have sufficient exposure to the UV rays. The time required to kill is variable, depending on the number and type of microbes, water quality, and on the intensity of the lamp. While minimal exposure may appear to have killed all pathogens, it has been shown that as many as two-thirds of these “dead” microbes can revive themselves if the “purified” water is stored in a warm place, such as on the kitchen counter. This problem relates back to the “how long do we boil the water?” question – per-

haps better rephrased as “What’s it take to kill one of these little buggers anyway?” Most manufacturers recognize this problem and design the housing of the UV lamp to facilitate maximum exposure of the water to the biocidal ways of radiation. This is known as the unit’s flow rate – the time required to purify the incoming water, in other words – which in this case is linked to the flow rate of your pump (rated in US gpm or L/min). Basically, the UV unit should be rated to handle about double the pump’s flow rate.

Because exposure time must increase as the microorganism count increases, a UV device is not recommended when the faecal coliform count exceeds 100 per ml of water. Fluctuations in voltage, a potential problem in rural settings, can also reduce a UV’s effectiveness. And speaking of rural electrics, it’s smart practice to plug the UV device into an uninterruptible power supply (UPS) with built-in voltage regulator and surge protector. This not only protects the device from the vagaries of rural electrical service, but also ensures that the treatment process doesn’t stop, even when the power is off. A few units now include these features as part of the package.

Complicating the issue of exposure time is the fact that the output of a UV lamp diminishes over time. A UV bulb is usually good for 9,000 hours, or about a year of continual use (and often less when operating under arduous conditions, such as when the water is turbid). Any UV system should have an audible alarm, and/or a visual alarm, that warns you when the lamp is no longer up to snuff, and perhaps a 365-day count-back to remind you when the bulb’s 9,000 hrs are over. If you’re going away for more than two or three days, unplug the unit so that the bulb isn’t on when the system is not being used (the count-back device only keeps track of the time you use the system). There is a slight risk of microbes repopulating a switched-off system, and the longer the system is down, the greater the risk. Fortunately, the remedy is easy: Open up the taps upon your return and run the water for at least five minutes to flush out any resident microbes while refilling the lines with purified water. Some units come equipped with a UV intensity moni-

ULTRAVIOLET RADIATION SYSTEM



The shining: By bombarding microbes with ultraviolet radiation, UV purifiers destroy their ability to reproduce and infect. Some systems include a sediment filter to remove particulates and an additional carbon filter for taste.

tor, which in theory is a great idea but as of this writing, many have experienced reliability problems, the resulting lack of warnings giving users a false sense of security, and maybe bad water. Just like regular lightbulbs, UV lamps come in a variety of power ratings. For reliable disinfection of all microbes, including protozoan cysts such as *Cryptosporidium* and *Giardia*, you want a UV lamp rated at least at 40 millijoules per centimetre squared (a measure of its intensity). And you want that intensity rating at the end of those 9,000 hours. (Note: Despite claims of being able to kill cysts, some manufacturers still recommend adding a one micron absolute filter to the system as a cautionary failsafe.) As a bonus, UV radiation will also destroy chlorine residuals.

UV rays can be blocked by dirt accumulating on the lamp, so a UV device must also provide a convenient way to access the lamp for cleaning (and replacement, for that matter). Some units are self-cleaning, however, a few of the cleaning devices have been known to leave microscopic scratches on the lamp's sleeve, which can diminish its effectiveness over time.

In common with distillation and boiling, UV treatment adds nothing to the water, and therefore nothing potentially nasty to your body or the environment. A UV lamp also consumes much less electricity than a kettle or distiller. Both POU and POE systems are available. Surprisingly, from an initial set-up cost perspective, and definitely from a cost of operation point of view, the two systems will cost about the same.

Expect to pay about \$1,000 and up.

Minimum requirements: electricity and water free of turbidity.

FILTRATION

A filter removes one or more unwanted substances from our drinking water by preventing the passage of those substances beyond the filter medium (just as a customs officer might do at a border). For filtration to be effective, we have to establish which substances we wish to stop, and then determine which filter can stop them in an

THE BLUE-GREEN (CYANOBACTERIA) BLUES

As this goes to press (2010), the scientific community and water treatment industry have yet to come to a consensus on how to solve the problem of cyanobacteria, a.k.a. blue-green algae, and rid the water of its potpourri of toxins for on-site systems. Therefore, if drawing your water from an affected water source the best, and perhaps only guaranteed solution, is to dig or drill a well at least 100' (30 m) away from the affected water, the further the better. You may still have to contend with removing contaminants, but at least it's a consistent and solvable problem.

However, because humanity can occasionally be almost as good at correcting its screw-ups as creating them, you might want to contact a reputable water treatment professional first, for maybe, just maybe, some new cyanobacteria treatment breakthrough might have come to fruition since the publication of this book. I say this with my fingers crossed.

acceptable time frame. From the perspective of drinking water, the first criterion is easily satisfied by an extensive water examination as outlined in Chapter 5. However, choosing an appropriate filter can be more difficult than searching for truth in a platform of election promises. (Oh, those fantastical flights of brochure hyperbole.)

One measure of a filter's ability to stop contaminants is its porosity or mesh size – the size of the holes in the filter medium that permit the water and whatever else to squeeze through and continue on their way. This is rated in microns, one micron being equal to one-millionth of a metre (about three-millionths of a foot), as opposed to a human hair which is about 75 microns in diameter. Simple science so far, at least until the scientists got involved. If a filter is rated at one micron “absolute”, nothing bigger than one micron is going to get through. The non-scientific community might call this the “truth”. Filters rated as “nominal” are only close approximations, so a one-micron “nominal” filter could let anything from two to three microns sneak past. The non-scientific community might call this a “politician's promise.” As for the microbes, your average bacteria checks in at around 5 microns and a virus at about 0.03 micron.

Judged by Max's Arbitrary Rules of Simplification (MARS), there are three general categories of water filters applicable to home and cottage use: tank, cartridge, and dumb. Not included in this review are the combination water filter/water jugs that have proved very popular in the city. These filters are designed to remove the taste of chlorine and other additives from limited amounts of treated water, but aren't considered suitable for use with untreated water.

TANK FILTERS

Tank filters are large canisters, usually made of steel or fibreglass, averaging 8" (20 cm) in diameter by 48" (125 cm) high, but the dimensions can certainly vary. Each tank may contain more than one filter medium – which is usually a loose fill poured into the tank, the tanks often connected

to other tanks, filters, and treatment devices. Because the quantities of filter medium are large, the capacity of the filter to deal with contaminants is also large, which translates into longer filter life, the ability to handle increased flow, the ability to filter out more contaminants, or some combination of the three. Tank filters generally serve as part of a POE system, meaning you can drink the bath water (before it hits the tub, unless you're a bit weird). Typical uses include water softening, sediment removal, iron removal, tannin removal, and neutralizing of acidic water.

Avoid any filter medium that contains a phosphate compound, such as polyphosphate (sometimes used for iron removal) and potassium phosphate (sometimes used as a water softener) due to their contribution to nutrient enrichment.

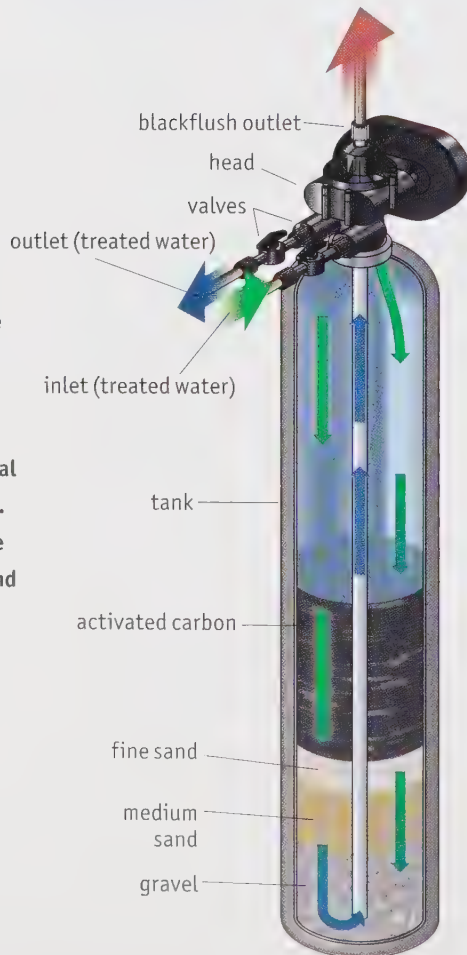
WATER SOFTENERS

Chemically, water softeners function in the same manner as fabric softeners, via an ion exchange program where negatively charged ions (anions) or positively charged ions (cations) from one substance bump out a similarly charged ion from another substance. In the case of a tank filter, incoming water passes through a bed of beaded resins that electrostatically swap resin ions for the selected ions in the water. For example, sodium chloride (salt) anions or calcium hydroxide (lime) anions can be traded for calcium and magnesium ions (the principle partners in hard water). The choice of resins is huge – enough to fill an entire book, in fact – so talk to a water treatment specialist if the answer to your specific problem is not discussed in this chapter (a specialist in this case being a knowledgeable person who deals only in water treatment solutions, with many options, and not the one-treatment-fits-all sort of shop). When the resin's ions get depleted, the resin is recharged by backflushing it with the appropriate substance (saltwater, for instance, in the case of sodium chloride).

A few cautions: Folks on a low-sodium diet and also reliant on a water softener to reduce hardness should add a reverse osmosis device to the system, one designed specifically to desali-

TANK FILTER

Volume dealer:
Because of the large amount of filter media they contain, tank filters have a greater ability to deal with contamination. They can also handle higher water flow and have a longer filter life than cartridge filters. Tank filters are generally part of a point-of-entry system.



nate water, the treated water then directed to a dedicated drinking water tap. And while reluctant to speak well of governments in general, here's one bit of good advice from the bureaucrats of Alberta: "Under no circumstances should any water softener be used for iron removal." (See backflushing, right.)

But there are instances, other than water softening, where an ion exchange system is worth considering, such as the removal of nitrates, nitrites, lead, mercury, arsenic, and – particularly for POE applications – radium and uranium (the type and amount of contaminant dictating the nature of the resin used).

OTHER MINERALS AND SEDIMENT

The most basic filter type common to both tank and cartridge varieties is the sediment filter. In the case of the tank filter, the traditional filter medium is sand, such as manganese greensand. Greensand grains are about 20 microns big (which actually isn't very big), while regular sand filter media checks in at about half that size, the choice between the two dictated by the contaminant being removed from the water. Greensand is typically injected with an oxidant, such as potassium permanganate, which causes the dissolved contaminant to precipitate out of the water to become a particle that becomes trapped in the sand. Other versions of the tank sediment filter use a combination of aeration, a proprietary filter media, and possibly gravel, usually incorporated into two or more separate tanks, with no chemical oxidants. Sediment tank filters are used to remove such irritants as silt (turbidity), iron (soluble, insoluble, and organic, but not iron bacteria), manganese, and hydrogen sulphide. When used to remove organic iron, the organics must be treated first, such as with a carbon filter (see p. 92).

Depending on intended function and options, the initial cost for tank filters can quickly get scary, but that may be offset by longevity and convenience. The cost of filter medium replacement depends on type and quantity, the fre-

quency dictated by water quality (the more stuff in the water, the quicker a filter's capacity to remove that stuff is consumed).

BACKFLUSHING

Many tank filters incorporate a backflushing system. This allows for periodic flushing of the filter medium (automatically or at the user's discretion), extending the life of the media. All good so far. In cottage and rural settings, tank filters are typically installed and plumbed to backflush into a septic system. *Wrong!* Any sudden and sizable influx of liquid unavoidably risks washing septic solids out into the absorption area (see Chapter 7), and the chemicals contained in a typical backflush may destroy the bacterial action in the septic tank. When it comes to water softeners, some jurisdictions, such as California, prohibit the discharge of the brine anywhere because of its deleterious effects on the environment, demanding that it be hauled away to an approved disposal site (just as required for septic tank pump-outs). Others, such as Alberta, simply caution against backflushing the brine into a septic system, claiming that can "negatively affect microbial activity" in the tank and reduce the ability of soil to absorb septic effluent. Perhaps as no surprise, many water softener manufacturers dispute these claims, some sending me stacks of paperwork to back up their objections. Having read it all, I find myself, for the second time this chapter no less, siding with government sources (I promise to try not to do it again).

For those with low-yielding wells or wells with lots of sediment settled on the bottom, backflushing presents an additional concern: The significant and continual draw on, and agitation of, the aquifer that backflushing normally demands risks running the well dry, or fouling the pump. The solution is to slow the process, perhaps by installing an inline flow restrictor. But check with the system's manufacturer first to ensure that such a solution will work with that tank system.

Depending on the contaminant being removed, some tank filters may need frequent

backflushing (those working to remove tannins, for instance). Frequent, fast, or slow flush, the backwash still needs to be disposed of. Where permitted legally, run the backflush discharge through an outdoor tap to a hose, directing it to a suitable spot in the yard. For example, we have a manganese greensand tank filter that takes care of iron removal from water coming from our drilled well. When installing the filter, I plumbed in an extra indoor water line running parallel to the existing line, the two systems meeting at a shared outdoor tap. Now, with a flick of a few shut-off valves, I can manually instigate a backflush, the backwash headed outdoors through the outdoor tap. From there, a hose directs the backwash to whatever area in the yard is in need of watering. Both the septic system and the vegetation around the house appreciate it, the latter sometimes even sending me flowers in appreciation.

If living in an arid region, it may be preferable to store the backwash in a water-storage container (see Chapter 2), the water to be used later – normally for irrigation – as required. As a bonus, solids tend to settle out in stored water. Depending on the water's quality, this may allow you to recycle the upper portion of the water-storage container's contents back into your water system (the point of entry preceding all treatment systems, the water then revisiting the same treatment process as before).

Prices start around a grand, increases dependent on the number of tanks, resin type (or types), and the number of fancy gewgaws.

CARTRIDGE FILTERS

As the name implies, rather than loose fill, the filter medium in this case is a manufactured cartridge, held inside a filter housing (also known as the sump). The normal industry-standard filter housing is about 10" (25 cm) high by roughly 3.5" (9 cm) in diameter, the cylindrical filter inside measuring approximately 9.75" (25 cm) long by 2.5" (6 cm) in diameter. There are also larger versions designed to hold larger filters, such as the so-called "Big Blue" which is about 4.5"

(12 cm) in diameter. And, to increase your options even further, both diameter sizes are available in longer 20" (50 cm) lengths. The shorter filters are typically used for POU filtration as the housings tuck away nicely under a sink, or sometimes sit head-side-down on a counter. But often, these filters will also see POE duty, which is where the bigger guys almost always hang out. Bigger costs more, but because of the increased contact area with incoming contaminants, larger filters can remove a greater number of nasties and require less frequent replacement.

Whatever the size, the wider blob, usually found at the top of the filter housing where the incoming and exit lines connect to it, is known as the head. Picture a fat wine bottle wearing a pork-pie hat (easier to do after emptying the bottle). The housing attaches to the head either via a bayonet-type fitting, which doesn't require tools, or via a threaded fitting, which requires a wrench-like device (usually supplied with the treatment system) to tighten the housing to the head. From my experience, the threaded version is easier to use, but costs more.

A typical treatment system will have two or more housings in tandem, the water flowing from one to the next in series. Cartridge filters are also often found in tandem with purifiers, such as distillers, UV devices, and reverse-osmosis units (more on these later). If the filter system lacks a shut-off valve on the head, add a shut-off valve to the incoming line when you install the filter. This allows you to change filters without turning off the water supply.

As a final note, beware those cartridge systems that come in unique shapes and sizes, and use proprietary filters. Some can get downright fancy, like objects of industrial art. Of course you're going to pay dearly for fancy, both in initial purchase price (which can approach the lower end of tank filters) and, more importantly, filter-replacement costs – your choices now restricted to a single manufacturer. Fortunately, the plebeian industry-standard cartridge filters perform at least as well, and offer you a much wider range of filters and replacement parts from which to choose.

CHOOSING THE RIGHT CARTRIDGE

SEDIMENT FILTER

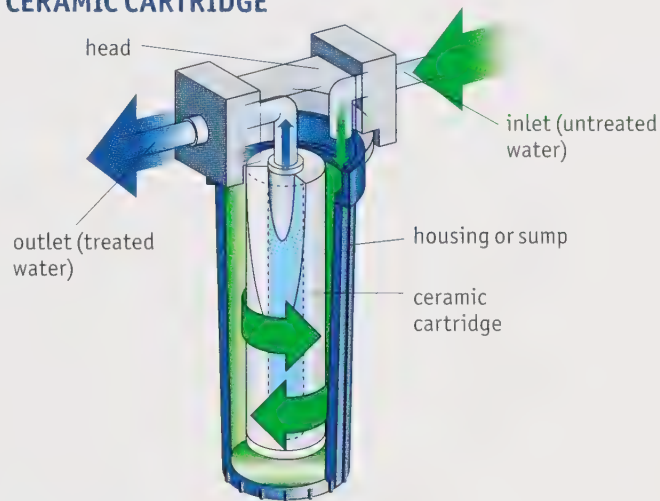
As with the tank sediment filter, the cartridge sediment filter takes out big chunks, in this case the bits in the 5-micron range. While a very fine filter will remove more contaminants, it will also tend to clog quicker, particularly when dealing with very turbid water. In such situations, one solution is to plumb two or more sediment filters in series, each successive filter having a smaller micron rating than the preceding one (for example, a 25-micron filter followed by a 10- and then by a 5-, or as required), which accomplishes the job while extending the life of the filters. A simpler solution, at least from the standpoint of plumbing, is to use a dual-gradient filter, which is two filters in one, the outer layer taking out the big stuff (a 25-micron, for instance) while the inner layer handles the smaller, 5-micron bits. Cartridge sediment filters can be made of foam, wound string, pleated fabric, paper, or plastic. The plastic pleated variety will usually last longer as it can be scrubbed clean with a brush a few times. While wound string can't be cleaned, it does provide more depth than a pleated filter, increasing its capacity to remove stuff from the water. Also, as the outer layer slowly becomes congested, filtration actually increases until, in common with all filters, the passages become overly restricted and, ta-da, it's time to replace the filter. Foam, fabric, and paper varieties can in some circumstances support bacterial growth within their pores, the filter medium acting as a food source for microbes.

CERAMIC FILTER

In addition to stopping sediment, a 1-micron absolute silver-impregnated ceramic filter (tucked into a standard filter housing) will also stop and/or kill bacteria and protozoa, including cysts such as *Giardia* and *Cryptosporidium* (at least when the faecal coliform count is less than 100 per ml of

water). The silver does the killing once the bacteria has been stopped and trapped by the filter's tiny pores and sharp, crystalline edges. Viruses, however, are small enough to sneak through the blockade unharmed. Those microbes and sediment that do get held up at the border will eventually block the filter, resulting in reduced flow, the lack of water letting you know that it's time to clean the ceramic cartridge. How do you clean it? Very carefully, folks, due to its fragility. Even invisible-to-the eye cracks are enough to let the microbes slip by. Also, if the water system is not used for a week or more, clean the filter upon return – the warm environment within the filter housing is an ideal place for microbes to replicate.

STANDARD FILTER WITH CERAMIC CARTRIDGE



Catch and kill:

Once trapped by the crystalline pores of a silver-impregnated ceramic filter, bacteria and protozoa are then killed by the silver itself. Viruses, due to their tiny size, are able to sneak through the trap, so ceramics are often partnered with a virus-killing purifier such as a UV or chemical treatment system.

To clean the filter, cut a half-inch strip from a kitchen scouring pad (the flat sheet variety) and gently rub the filter's surface until the outer film of scum is removed. Unfortunately, each cleaning also removes some of the ceramic, the cartridge's effectiveness to filter diminishing with each cleaning. After repeated scrubblings, the filter will have to be replaced. Some manufacturers include a gauge to measure the cartridge's thickness, letting you know when it's time to replace it, but

typically the original cylindrical shape will tend to take on the slim-waisted look of an hourglass.

A ceramic filter partnered with a purifier capable of killing viruses (such as a UV device or chemical treatment) will stop all pathogens (assuming the water is clear, a goal made easier when a sediment filter is used as the first line of defence). If the source water has a faecal coliform count greater than 100 per ml, frequently test the treated water to ensure that the system is producing potable water.

CARBON FILTER

A carbon filter, also known as a charcoal, an activated-carbon, a granulated activated-carbon (GAC), or an activated-charcoal filter, will also remove a certain amount of turbidity. But its primary function is to remove disagreeable tastes and odours (from hydrogen sulphide, or chlorine or iodine disinfection, for instance). More importantly, it will also remove organics (such as tannin, methanes, iron bacteria, pesticides, and herbicides), certain toxins – such as cyanotoxins – and radon gas. Through a process known as adsorption, activated-carbon filters attract and accumulate most of these water-borne contaminants. However, sediment can quickly clog the fine pores of a carbon cartridge so a sediment pre-filter is required if the water is turbid. Tank carbon filters, however, are usually large enough to remove sediment without risk of clogging. Unfortunately, whether in a cartridge or a tank, charcoal attracts bacteria, allowing the microorganisms to proliferate in its pores. Therefore, water carting along microbes is usually first disinfected (by distillation, ceramic filter, chemical treatment, etc.) before passing through a carbon filter. That said, if grow-back (see Chapter 5) is energetic, microbes can theoretically reach the carbon filter from the tap end and start proliferating to the point that it becomes a health issue. For this reason, some purifier manufacturers place the carbon before the disinfection process if the target contaminant is in the source water, rather than introduced as part of the purification process (such as with chlorine, for instance).

The better the carbon, the more stuff it removes and the longer it lasts. The more contaminants that pass through a carbon filter, the quicker the activated carbon is “consumed,” another good reason to have a sediment filter precede it. Checking the list of things a carbon filter removes is one way to judge its quality, and generally, a better-grade carbon filter will cost more and weigh more than one of lesser quality. Also, carbon is sometimes rated by its ability to remove chloroform or iodine, a rating of between 12 and 16 being a very good carbon filter, a 4–8 rating not so good.

A cartridge filter with housing starts at about \$50, replacement cartridges setting you back about \$10–\$50, depending on type.

DUMB FILTERS

Dumb filters simply clip or screw onto the end of your tap. With the water exposed to so little filter medium, the benefits of filtering are at best marginal – as is the filter’s longevity in typical use. Cheap to buy, but not worth the price in my not-so-humble opinion.

All filters and filter media deteriorate and require replacing, the exact timing impossible to call, except to say that it will likely occur before manufacturers’ recommendations. A filter or filter medium that is spent and not replaced could add contaminants to your drinking water.

Filtration has no residual effect.

Minimum requirements: water pressure, a recharging agent (if required), and a suitable place to discharge the backwash (if required).

SOLUTIONS FOR DEALING WITH ZEBRA MUSSELS

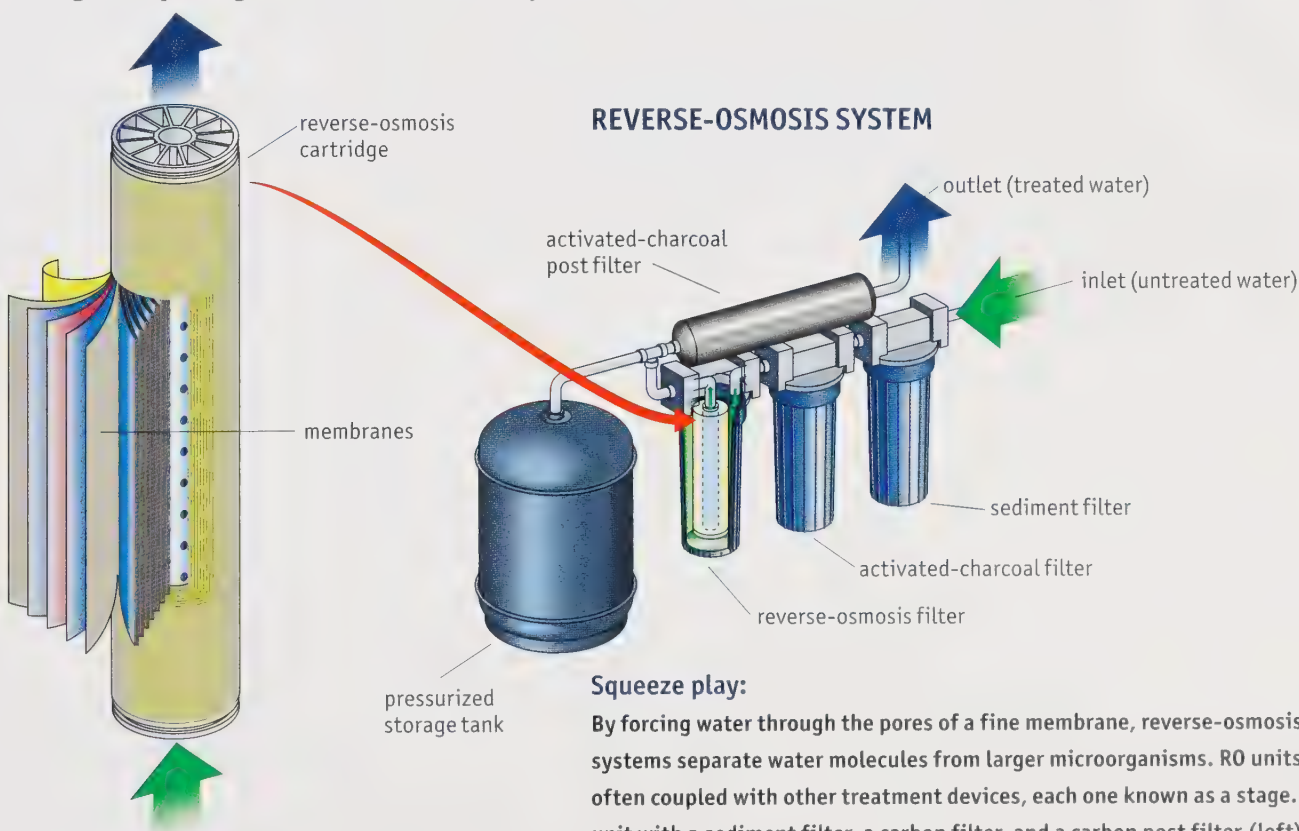
The first solution is to prevent them from getting into your water system, right from the start of the intake line. A study done by Ontario’s Ministry of the Environment determined that, if placed before the foot valve or intake for a submersible pump, filtration can work. A pleated filter around 30–60 microns will usually do the trick, as do a few foot-valve sock filters, but either

will need frequent cleaning and replacing. You can piece together your own system or, for those less inclined to fabricate things themselves, buy one specifically designed for that task. The second, much more expensive option is to put in a well. It's a tough world out there sometimes. The third option is to simply ignore the problem. In many cases (but not all), these minuscule mussels haven't lived up to their billing as the next great dastardly problem for water intake lines, the water often getting past the mussels accumulated on the foot valve, and the veligers (the larvae) not surviving the trip through the water system. If your water system works in zebra mussel infested water, why fix it?

REVERSE OSMOSIS

In a reverse-osmosis unit (or RO, as it is known in the trade), water is forced through the pores of a fine membrane. Everything too big to squeeze through the pores gets left behind. In theory,

anything bigger than a water molecule shouldn't make the grade, but in practice, because the size of the pores varies, some microorganisms can sneak through. Reverse osmosis will remove organic chemicals, toxic minerals, tannin, and arsenic, but not tastes, odours, or radon gas. With the right type of membrane, it can also remove radium and uranium, but this use is best suited to POU applications only. To rid the system of all pathogens, a UV device or chemical treatment would have to follow the unit. Iron, manganese, sulphur, and turbidity can decrease the life expectancy of the membrane, so an RO unit must be preceded by a sediment filter. Theoretically, membranes can last up to five years, although that's rare. Usually, economical total dissolved solids (TDS) testers are used to measure membrane effectiveness, the amount of chunks in the incoming water compared to the chunks in the treated water. When TDS rejection is less than 75%–80%, the membrane needs to be replaced. If tastes and odours are a problem, a carbon filter will have to be installed after the unit. In RO jar-



Squeeze play:

By forcing water through the pores of a fine membrane, reverse-osmosis (RO) systems separate water molecules from larger microorganisms. RO units are often coupled with other treatment devices, each one known as a stage. An RO unit with a sediment filter, a carbon filter, and a carbon post filter (left) is known as a "four-stage RO."

gon, each individual treatment device is known as a stage, meaning that an RO with a sediment pre-filter and a carbon pre-filter – the typical minimum system – would be known as a three-stage RO. Expect to pay a little more for an RO system than a tank filter set-up or distiller.

WILL IT WORK FOR YOU?

Reverse osmosis requires a minimum incoming water pressure of at least 35–40 psi. As most rural or cottage non-submersible water pumps don't meet this standard, make sure the RO unit comes with an auxiliary booster pump as part of the package.

Typically, an RO system takes about 3–4 hours to treat 1 US gal (4 L) of water, and wastes 3–9 US gal (10–35 L) in the process. (The leftovers are known as the brine.) Unfortunately, this waste water invariably ends up in the septic system, an additional load it certainly doesn't need (see Chapter 7). A better use for waste water is to use it to irrigate the yard, as described above for backflushing, or pump it into a storage container, to be used later for irrigation.

There is no residual effect for reverse osmosis.

Minimum requirements: consistent water pressure of at least 35–40 psi.

OZONATION

Ozone is a gas, O_3 , consisting of three oxygen atoms (the oxygen we breathe, O_2 , having two, surprisingly). Ozone is usually created every time an electrical discharge passes through the air. Lightning will do the trick as will starting an electric motor or, for purifying water, by using an ozonator. Ozone is the strongest practical disinfectant in our arsenal, working in the shortest contact time, using the smallest doses, killing microbes by destroying a cell's walls. It has also been shown to deactivate some toxins, such as some cyanotoxins (see Chapter 5), though as of 2010 the jury is still out on the consistency of its effectiveness for such uses. Ozone can also

be used as part of a manganese removal system, causing the dissolved manganese to precipitate into particles that can be then filtered out. Excessive amounts of iron, sulphur, and turbidity will interfere with the disinfection process, so a sediment filter might be needed prior to the ozonator to remove such contaminants.

Batch and inline ozonators are available for both home and cottage use, costing about the same to purchase and to operate as comparable distillers. Any attached reservoir will require frequent cleaning. And while ozone in the stratosphere is good, protecting us against excessive UV rays from the sun, ozone from down here (known as ground-level ozone) is not, its presence causing respiratory problems, headaches, burning eyes, and weather checking on tires. And every time you use an ozonator, small amounts of ozone escape into the lower atmosphere.

Ozonation has a short residual effect, the unstable O_3 molecule quickly decaying into O_2 .

Minimum requirements: electricity and water free of turbidity.

AERATION

Technically, any introduction of air into water, such as with an air-injection pressure tank, could be classified as aeration. However, from the perspective of water treatment systems, aeration involves feeding a great deal more air through the water, and then providing a means for that air to vent out to the atmosphere. Typically, this is accomplished using either the waterfall method, where the water passes through the air, or the bubble method, where the air passes through the water. In both cases, it all happens within an enclosed tank, the intake air taken from outside, or from inside the building from an area devoid of moisture and debris, the exhaust air always dispersed outdoors, preferably 3' (1 m) above the highest point of the roof to avoid back drafts (the exhaust air will likely contain hazardous gases).

Aeration will remove gases, such as hydrogen sulphide, VOCs, and radon, and can be used to precipitate insoluble iron out of water for fur-

ther treatment in a suitable sediment tank filter. It will not remove microorganisms.

The complete system takes up a fair bit of room, and requires considerable maintenance, the aerators and storage tanks subject to biofouling. Depending on what's in the water, frequent cleaning, disinfection, and backflushing may be required. Also, other treatment systems, connected in series, will likely be needed to ensure healthy drinking water.

Aeration has no residual effect, with electricity needed for air pumps and possibly auxiliary water pumps.

CHEMICAL DISINFECTANTS

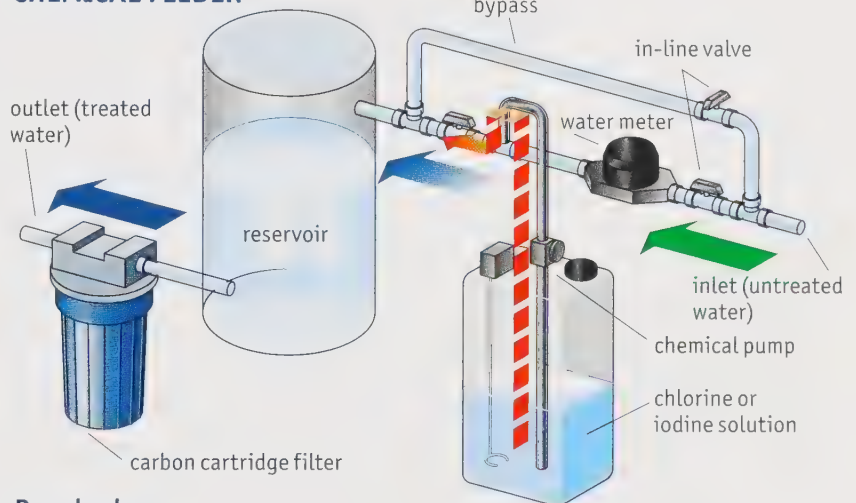
Thanks to the wonderful world of chemical compounds, we have four more ways to conveniently slaughter microorganisms: chlorine injection, shock chlorination, iodine injection, and demand-release iodinated resins, also known as pentaiodide.

CHLORINE

Chlorine gas is the disinfectant of choice for municipalities throughout North America. This is an extremely dangerous substance, used during World War I to kill humans, but fortunately a much less toxic liquid version of chlorine is available for home use – sodium hypochlorite, better known as chlorine bleach. (Note: Not all bleaches are created equal, the percentage of sodium hypochlorite varying from about 3%–6%. Javex, at 5.25%, is the usual recommended standard.) Bleach works well for purifying smaller quantities of water and for shock chlorination of wells (see p. 96) but for ongoing treatment with a chemical feeder, the chlorine killing ante is usually upped to calcium hypochlorite (see p. 97). Typically, a chemical feeder (in this case called a chlorinator) automatically injects chlorine into the incoming water line, the percentage of the chlorine added to the water being constant regardless of how many microorganisms may be

in the water at that time. (This system is not legal in all jurisdictions of North America.) For house and cottage use, safe doses of chlorine must be in contact with the water for about 20 minutes to be effective, so a large reservoir may be necessary if water use is high. But at these minimal levels, chlorine will not kill all cysts. A charcoal filter installed after the chlorinator will remove any taste and odour of the chlorine, and a 1-micron absolute pre-filter will remove the cysts. Turbidity will reduce chlorine's effectiveness (the particles absorbing the disinfectant), as will high alkalinity (higher pH values), so once again, a sediment filter must precede the chlorinator. Chlorine can also increase the toxicity of some undesirable chemicals that may already exist in the water supply.

CHEMICAL FEEDER



Drop by drop:

A chemical feeder, typically used to treat water with chlorine or iodine, automatically injects incoming water with a constant percentage of treatment chemical. A reservoir is usually required to ensure chemicals stay in contact with the water for a prescribed time period. Chemical feeder systems often include other filters to remove cysts and improve taste.

In addition to disinfection, chlorination is sometimes used to precipitate iron, manganese and hydrogen sulphide from water, the suspended material and chlorine taste then removed from the water by filtration. And in common with ozone, it has been shown to deactivate some forms of cyanotoxins, but again, not all of them and not always consistently.

A complete chlorination system, which includes the chemical feeder, a reservoir, sediment tank filter, and a charcoal tank filter, starts at around \$4,000, while calcium hypochlorite runs about \$30 per gallon (depending on quantities and strength).

Chlorine has a strong and noticeable residual effect.

Minimum requirements: electricity, water pressure, and water free of turbidity.

SHOCK CHLORINATION

Shock chlorination, also known as superchlorination, is a technique used to disinfect wells. Whenever a new well is constructed, or an older one rehabilitated, the well and house or cottage water system must be “shocked” with a large overdose of chlorine, purging the entire system of microbes. Regardless of your feelings about the use of chlorine, there is no other acceptable means of ensuring that the water will be safe for later use. As to how much chlorine is needed, it depends on two variables. The obvious one is how much water do you need to disinfect, which depends on how much water is in the well, a fac-

tor of well diameter and water depth (not well depth). The other variable is jurisdictional predictions, which will necessitate a visit to your local health department and/or government agency responsible for water quality for the shocking specifics (most have handy charts that give the quantity needed based on well diameter and water depth).

As a ballpark well example, for the ever-popular 6" drilled-well, you will need about 1⅓ US pints (0.6 L) of household bleach (5.25% sodium hypochlorite) for every 100' (30 m) of water depth. (Note that liquid bleach does lose its potency over time, so try avoid buying old stock, and use it soon after purchase.)

For a new well, dump in the required amount of chlorine, then mix it in by pumping the chlorinated water back into the well via a clean hose. (The chlorinated water should not be run through any house or cottage filtration system.) Let the well sit for at least 12 hours, then rid the well of chlorine by pumping the water out into the yard (not the septic system) until the presence of chlorine is no longer detectable by taste or smell (or barely detectable).

For an older well being rehabilitated, also disinfect the indoor pressure lines, including all water treatment devices except carbon filters (they remove chlorine), running it through each outlet until you can smell the chlorine coming through. If there's a tank filter that gets the occasional backflush, do that too. Let it sit, then get rid of the chlorinated water as above.

Minimum requirements: a well or water system in need of disinfection and a bottle of bleach.

RESIDUAL EFFECT AND STORAGE

A method of water purification is said to have a residual effect when it continues to function as a purifier after the initial contact with the contaminated water. For example, chlorine can hang around for a while in pipes, bumping off microbial invaders, while boiling only kills what's there at the time.

Post-purification microbial invasions can be curtailed by proper storage. The best place for disinfected water is in a cool, dark place, like the refrigerator, and it should be consumed within a couple of days following initial purification. Water left in a cottage water system between visits (and usually at summer temperatures considered ideal for bacterial growth) should not be considered safe to drink. Boil it for an initial cup of tea and then run the taps for about five minutes to flush out the nasties.

The container material of choice is glass. Water will pick up the taste, and sometimes the chemical constituents, of plastic containers (with the possible exception of certain polycarbonate and HDPE containers).

SHOCK CHLORINATION AND IRON BACTERIA

Iron bacteria is nasty stuff. Once established in an aquifer, it can be extremely difficult to eradicate, typically requiring ongoing chlorination or demand-release iodinated resins. However, if discovered before becoming entrenched, it may be possible to eliminate it. The trick is to catch it in time. For new wells, if iron bacteria

isn't a problem for other wells in the area, then typically it's introduced into the aquifer during well construction, via a drilling rig, the lubricating water for the drill, or water used during hydrofracturing. Basically, anything used in well construction, or being put into a well, should be disinfected. (To paraphrase my mother, "Don't put that in your well; you don't know where it's been!"). Good advice, but impossible to carry out from a practical standpoint. So as soon as iron bacteria is discovered (see Chapter 5), opt for heavy-duty shock chlorination.

HEAVY-DUTY SHOCK CHLORINATION

As with regular shock chlorination, the amount of chlorine required depends on water quantities and jurisdictional preferences but for the heavy-duty version, expect to use about seven times the amount of household bleach. In fact, most jurisdictions usually recommend a more concentrated version of chlorine, calcium hypochlorite (weighing in at about 6.5%, instead of 5.25%, available chlorine). Again, check with local authorities for area specifics. Calcium hypochlorite comes in either granular or tablet forms (look for it at chemical supply distributors, well installers, or pool supply stores).

Methodology also differs from regular shock techniques. Now, the chlorine must be premixed with large quantities of water pumped from the well, the mix slowly fed back into the well. Using the 6" diameter well as an example again, you would need anywhere from 100–290 US gal. (375–1,100 L) depending on where the well is located. (For area specifics, talk to local bureaucrats again. Sorry.) As for what to mix it in, new, clean plastic garbage cans typically hold about 30 US gal. (100 L), so anywhere from four to 11 of those should work (which is a lot of cans to contend with).

Once the chlorinated water is all back in the well, recirculate it in the well (as done for normal shock treatment), forcing the chlorine deep into the aquifer. Then, run the chlorinated water through the house or cottage pressure sys-

tem (bypassing or removing any carbon filters), including backflushing any tank filters that require it, and let the whole system sit undisturbed for at least 24 hours. When it comes time to flush the well and pressure system, discharge it outdoors but away from any well, waterway, sewage system, or sensitive flowers and shrubs. Which leads me to this warning: Calcium hypochlorite is a hazardous chemical, very corrosive, and contact with skin can cause burns. It also absorbs moisture readily, making it tricky to store, so you may want to hand this job over to a well contractor experienced with the task.

CHLORINE'S LEGACY

One of the things we like about chlorine is that it hangs around. This means that as a disinfectant, it has a residual effect. Though it oxidizes quickly once exposed to air, as a chlorinated molecule it can last forever (give or take a millennium). In industry, this tenacious nature of a chlorinated molecule has encouraged chlorine's use in plastics, fabrics, glues, and building materials because it adds durability to the products. But its propensity to persist also means it hangs around in the environment, something we're not nearly as keen on.

Chlorine on its own is very reactive: It's a chemical street walker – always looking for a mate, and you know it's going to cost. For instance, chlorine readily mates, often unintentionally, with organic compounds to form dioxins, trihalomethanes such as chloroform, and halomethane acids such as chloroacetic acid. And there seems no end to its promiscuity, with new matings happening as you read this. Because the water we treat inevitably ends up in our septic system, which is essentially an ocean of organic compounds, the likelihood of forming known and suspected carcinogenic compounds is high, as is the likelihood of any of these newly created toxins leaching out into the environment. And, thanks again to the persistence of chlorinated molecules, these toxins and compounds will probably be here for a long time to come. Longer than taxes even.



CHARTING THE WATERS

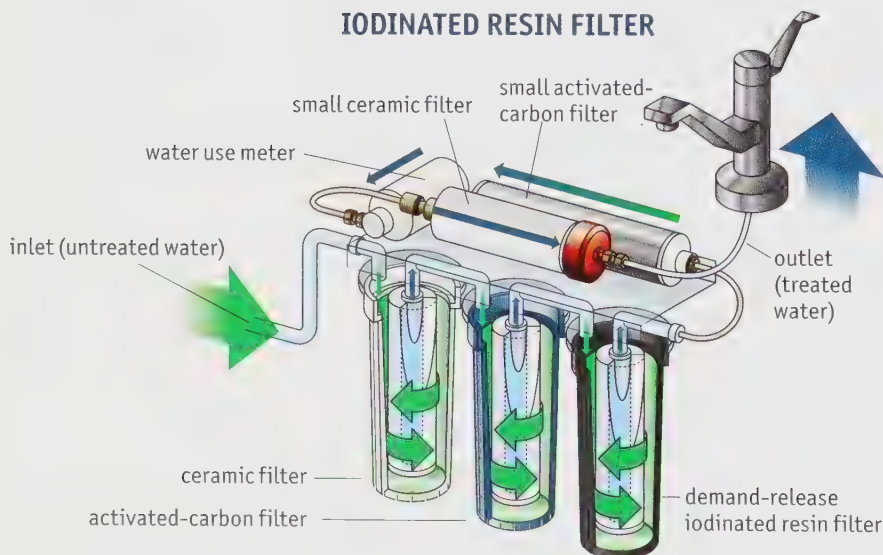
PROBLEM	PROBABLE CAUSE/ COMMENTS	POSSIBLE REMEDY <i>(see text for further explanation)</i>
COLIFORMS REVEALED BY BACTERIOLOGICAL ANALYSIS	faeces from warm-blooded animals getting into water supply	–boiling –distillation –UV –ceramic filter –chlorination –iodine injection –demand-release iodinated resins
BLUE-GREEN ALGAE (CYANOBACTERIA) revealed by an algae bloom or mat covering a large area of the water surface and typically also along the shoreline	excessive nutrient load from agriculture and faulty septic systems	–drill a well or wait for the bloom to disappear, then test the water for any remaining presence of the algae
TURBIDITY (suspended and dissolved solids other than those listed below)	sand particles, algae, miscellaneous vegetable matter	–distillation –sediment filtration
RED STAINING ON FIXTURES, METALLIC TASTE	excess iron (often accompanied by manganese)	–distillation –chlorination –manganese sulphate/potassium permanganate filtration –manganese greensand filtration (for organic iron, treat first with activated carbon filtration)
BROWNISH STAIN OR SLIME ON FIXTURES, COFFEE AND TEA TURNS BLACK AND BITTER TASTING	iron bacteria and/or manganese bacteria a) tannins (tannic acid)	–initial superchlorination using strong concentration of calcium hypochlorite - If that fails: –annual superchlorination and ongoing chlorination –drill new well a) –tank filter with tannin specific resin

PROBLEM	PROBABLE CAUSE/ COMMENTS	POSSIBLE REMEDY (see text for further explanation)
BAD TASTE AND ODOUR a) odour only from hot water	methane gas, hydrogen-sulphide gas, chlorine, iodine, or composting organic matter a) water heater magnesium rod used in tank to mitigate corrosion reacts with sulphur to form hydrogen sulphide	–aeration –boiling (if allowed to vent) –distillation –activated carbon filtration
PLUMBING FIXTURES CORRODING, METALLIC TASTE	acidity (pH >5, <7) a) acidity (pH <5)	–neutralizing filtration (marble and/or limestone chip) a) –soda ash injection
NASTY TASTE, SCALING ON KETTLES AND PIPES, UNSIGHTLY BATHTUB RING	excessive hardness	–water softener –distillation (clean boiling chamber often)
CHEMICAL ANALYSIS SHOWS PRESENCE OF ORGANIC CHEMICALS (VOCs, pesticides, petrochemicals, etc.)	agricultural/industrial pollutants	–distillation (except VOCs) –aeration –activated carbon filtration
CHEMICAL ANALYSIS SHOWS PRESENCE OF RADIONUCLIDES a) radon gas b) radium c) uranium	industry/nature	a) –activated carbon filtration –aeration b) –water softener (lime or salt) POE –reverse osmosis POU c) –water softener (lime or salt) POE –reverse osmosis POU
CHEMICAL ANALYSIS SHOWS PRESENCE OF TOXIC MINERALS a) arsenic	industry/nature	–distillation –activated carbon filtration a) –distillation –water softener –reverse osmosis
CHEMICAL ANALYSIS SHOWS PRESENCE OF NITRATES	agriculture/faulty septic systems/nature	–distillation –water softener

IODINE

Like chlorine, iodine comes in tablet, crystal, and liquid forms that can be used to disinfect water. Another trait shared with chlorine is how the potency of these varieties of iodine diminish with use and dilution in water. But because iodine is an element and not a chemical compound, such as chlorine, its potency does not diminish with time. And as of this writing, there's no firm evidence of deleterious long-term effects resulting from iodine's usage, though iodine is suspected of causing thyroid problems and affecting people prone to allergies. Iodine is not known to react with organic compounds to form potential carcinogens, nor are its disinfection properties diminished as pH levels increase. It does however require 50% more contact time with the water than chlorine (about 20 minutes for most microbes; hours to kill cysts), and costs about 20 times more. On the upside, should a nuclear holocaust occur, iodine will slow some of the effects of radioactive fallout, which is handy. Like chlorine, it has a residual effect on microorganisms, and its potency can be diminished with turbidity. The taste and odour it imparts to water can be removed with an activated-carbon filter.

IODINATED RESIN FILTER



Treatment as required:

Demand-release iodinated resin filters release disinfectant only as contaminated water flows past. When a water-borne nasty comes in contact with the resin, the iodine binds to the microbe and quickly kills it.

ter, which also reduces potential side effects. Iodine injection systems are comparable in price to chlorination systems.

Minimum requirements: electricity, water pressure, and water free of turbidity.

DEMAND-RELEASE IODINATED RESIN

Demand-release iodinated resins take a slightly different approach. The iodinated resin is held in a cartridge, similar in concept to a cartridge filter, the water coming into contact with the disinfectant, rather than the disinfectant being added to the water. When a microbe comes in contact with the resin, the iodine electrostatically binds to the microbe (much like the ion exchange happening in a water softener), hence the term demand-release. The contact time required to kill the incoming microbes is reduced to about two to three seconds and, despite it being a considerably more potent form of iodine than free iodine, because only the iodine required to kill each microbe gets into the water, a lot less disinfectant ends up in our bodies and the environment. Unlike chlorine or free iodine, demand-release iodinated resin will kill *Giardia*. But in common with all purifiers, turbidity will diminish its effectiveness and shorten its lifespan, so sediment pre-filters will likely be required. The resins also eliminate the handling and mixing required with chlorine and iodine injection methods. A typical unit with pre-filter will cost about \$400 and up, though the price can approach that of a full chlorination system depending upon the quantity of purified water required. Replacement resin cartridges cost about \$130–\$400, depending mostly on size.

Minimum requirements: electricity, water pressure, and water free of turbidity.

IODINE CAUTION

A few jurisdictions, such as Ohio and California, categorize any substance containing iodine as an insecticide, and therefore not safe to use in potable water. No distinction is made between

free iodine and demand-release iodinated resin, though the resin is specifically endorsed for use as a water purifier in many areas of the world.

SODA ASH

Just before leaving the wonderful world of chemical compounds, highly acidic water (having a pH level less than 5) can be neutralized with a solution of soda ash fed into the incoming water using a chemical feeder similar to those used for chlorine and iodine solutions.

Minimum requirements: electricity and water pressure.

NON-ELECTRIC SOLUTIONS

From the standpoint of having access to readily available drinking water, the real problem facing ruralists and cottagers without electricity is not the lack of electricity but the lack of water pressure. Water needs to be pushed through filters and purifiers. A typical water pump provides a minimum pressure of 20 psi. The less push provided, the slower the water is processed through the filter medium until at about 2 psi, the flow generally stops. Fortunately, there are ways around this problem.

BOTTLED WATER

Perhaps the most obvious choice for safe drinking water when there's no electricity, or your needs are small, or the cost of purifying your well or lake water proves exorbitant, is to purchase bottled water and schlep it home or to the cottage. Most bottled water undergoes treatment using variations of the systems discussed above, only on a grander scale. Personally, I have a lot of difficulty rationalizing spending money for something called "pure spring water" or the like when I can draw my own water from an artesian spring that, while safe to drink, is anything but pure. Personal prejudices aside, buy from a reputable dealer or manufacturer.

Sporadic exposés conducted by consumer groups and government agencies have brought to the public's attention, usually via sensational headlines, that not all bottled water is created equal, and some of it is created rather poorly. While such announcements are usually followed by hot and heavy debate over the testing methods used and the legitimacy of the findings, a very important point is regrettably overshadowed by all the brouhaha: The bottled water that passed these tests is unquestionably of high quality.

The trick is to purchase only the brands belonging to the International Council of Bottled Water Associations, or one of its chapters, such as the Canadian Bottled Water Association. Member companies must undergo annual, unannounced plant inspections by an independent, internationally recognized third-party organization. Refuse the test, or fail, and they're out of the club. The unfortunate reality is that most large-scale bottled water producers don't belong to the club.

The only residual effect is the plethora of empty plastic bottles that end up in the garbage or lining our ditches.

Minimum requirements: Thirst and the money to buy the water.

DISTILLATION BY THE SUN

An interesting variation on the batch distiller is the solar distiller. If you have ever witnessed condensation forming on a window, then you are already familiar with the basic principle. Untreated water is placed under an angled piece of glass; the sun heats the water, vaporizing it, and the vapour rises, condensing on the underside of the glass. It then trickles down into a catchment trough, and from there into a bottle. Yield is minimal even on a clear day – it depends on ambient temperature and the distiller size and design – but on average, expect about 1 US gal. or 4 L for every 10.7 sq. ft. (1 square metre) of distilling area, and about half that on cold days. (Outdoor solar distillers are not an option in winter for areas subject to freezing.)

Solar distillers are not difficult to make, but do require some careful attention to construction

details in order to maximize the available heat and keep airborne microbes from intruding into the purified water. Companies such as SolAqua offer plans, kits, and complete units (should you opt for the easy way out).

Contrary to myths published by some proponents of electric water distillers, it is not necessary to boil water to kill microbes, as temperatures just shy of that mark will do the dirty deed given enough time, as solar distillers typically do. Granted, boiling works much faster, typically assassinating everything that needs to be killed in five minutes or less, but a solar distiller's lower operating temperature will still work, just in a more slothful manner. However, one point that can't be argued is that you could get a might thirsty on a cloudy day. Yet for many warmer sites without electricity, solar distillation remains a dandy, though slow, way to purify water, and certainly the most environmentally-friendly purification system, bar none.

Minimum requirements: Sunshine.

Residual effect: None.

COMMERCIAL NON-ELECTRIC PURIFIERS

While still on the subject of distillers, there are a few non-electric portable distillers that work much like their electric counterparts except for the heat source, which is now a gas stove, camp stove, gas grill, or woodstove. Realistic yield is about 8 US gal. (30 L) per day, rain or shine. And by using the camp stove or gas grill, the heat produced from distilling can now be vented outside, rather than inside, should that day be a hot one.

One way around the problem of the missing water pressure that typically plagues an off-the-electrical-grid system is to create some of your own by erecting a water tower fed by a hand pump. Even a small water container, such as 5 US gal. (20 L) loft-mounted water bucket, can yield 5–10 psi, enough to operate most portable treatment systems. And, bonus, a water tower can offer enough pressure to operate flush toilets, and maybe a feeble shower too. The key is water tower size and height, the bigger and higher the

more pressure – both to feed the water system and, sadly, to raise the water up there. Keeping the container filled maintains the pressure.

A sampling of gravity-fed systems reveals that for less than \$500, you can easily have your water and safely drink it, too. One demand-release iodinated resin counter-top system made by DSMI Water and Air Purification will handle about 1,190 US gal. at about a pint per minute (4,500 litres at half a litre per minute), needing only 5–10 psi. Two filter housings sit upright, side by side, a composite ceramic with carbon block inside the first, and a composite iodinated resin and carbon in the second. The unit consumes about 5" x 10" (13 cm x 25 cm) of counter space, not including the spout. The residual effect is modest, the same as for its bigger, pressurized pals.

There's also an under-the-counter UV system that operates on a 12-volt battery. And thanks to battery power, this is one UV not subject to the variabilities of the normal electrical grid. But again, you need at least 5–10 psi, and depending on incoming water quality, you may need some pre-filters.

The simplest commercial purifier for non-electric sites is the gravity-fed, silver-impregnated ceramic cartridge filter, no water tower required (though some versions will process water faster with the added pressure of a tower). Picture two buckets, one sitting on top of the other, the upper one holding the filters and untreated water, the lower bucket holding the treated water. They come in two and four cartridge models, but the one to buy is the four-cartridge model because, due to its larger size and greater filter surface area, it yields more treated water than the two-cartridge unit, anywhere from 13 US gal. (48 L) to 21 US gal. (80 L) in a 24-hour period. With gravity-fed ceramic systems, even the slightest amount of dirt accumulating on the surface of a cartridge will dramatically slow flow, so it's imperative to keep the ceramic cartridges clean. Also, keep the upper bucket topped up for greater pressure and, hence, faster flow-through.

Minimum requirements: Source water free of turbidity.

A FREE IDEA

While the family snoozes through the night, all sorts of stuff can be happening in the plumbing system – such as toxic metals leaching from the pipes into the water and rude microbes partaking in an all-night orgy of replication. All this and more could be waiting to greet the dawn at a tap's first opening. So first thing in the morning – and when you return home or to the cottage after an extended absence – run the water for a couple of minutes to clear the pipes, usually until it's cold.

FINAL THOUGHTS ON WATER TREATMENT

All purification equipment is going to require maintenance, usually more often than indicated in the brochures. If your water source is seriously contaminated, it may be more economical in the long run (and certainly more convenient) to drill a new deep well. Of course, there's no guarantee water from that source will be trouble free, but the odds are with you that the problems will at least be consistent.

Parts of a septic system

Types of tanks

Absorption areas

Raised beds

Aerobic systems

Reducing the system's footprint

Why things go wrong

Care and feeding

Effect on the environment

Septic dos and don'ts

Troubleshooting guide

7. DEALING WITH SEPTIC SYSTEMS

There's a lot going on at the other end of the pipe

ON AVERAGE, EACH North American ruralist produces 80 US gal. (300 L) of sewage per day from all sources, while cottagers check in at around 50 US gal. (200 L) per day. Yet this is evidently no match for city folks who, apparently, are much better at dishing out the dung: City sewage-treatment systems are usually designed to handle 200 US gal. (750 L) per capita per day. While it's good to know that someone is keeping track of these things, you might want to avoid engaging in conversation with them at a party. Still, those are the figures – our combined individual contribution to the dilemma of dispersal. Where does it all go? In the city, one flush (or maybe two) and it's gone, thank goodness. And it's the same with the stuff we chuck down the kitchen drain – gone and forgotten. Who cares where it goes?

We all should, especially those of us with rural homes or cottages, because now our sewage is not some faceless city's problem, but ours. In the country, there's a good chance that whatever we flush or let drain away is headed for that

much-neglected and misunderstood slave, the septic system – and from there, into and often onto the property around us, and then perhaps into the waterways we swim in, and sometimes even into our source of drinking water. So a flush of the toilet only removes sewage from our immediate sight, it doesn't make it disappear. And while it's usually easy to distance ourselves from the workings and failings of a public sewage system, with a septic system, our private sewage-treatment plant sits not more than a few feet from our door. It's an integral part of the landscape. And as owner-operator of this system, it is perhaps the most significant area where individually, and without undue inconvenience, each of us can make a noticeable difference in maintaining (or improving) the quality of our environment.

In order to assume one's obligations as owner-operator, it's necessary to understand how a private septic system is supposed to work. The following is an overview of the most common sewage solutions, beginning with the basic tank

and leaching bed. But be forewarned: Even if restricted to a single continent – North America, for instance – the regulatory world remains flush with jurisdictions, each with a host of agencies looking after such matters, all with their own take on how best to handle sewage. So exact construction details and approvals still have to come from the authority presiding over such matters in your locale – hereafter referred to as the sewage police. The systems examined here all have one thing in common – minimizing our impact on this planet we all share. Therefore, the dispersal of raw sewage or partially-treated sewage out onto the ground, or into a waterway or private lagoon, or whatever similar option that might be legal in your area, is not covered here. It is this author's conviction that such dispersal methods merely pass the obligation buck, and therefore do not constitute a private sewage-treatment system but, instead, a public concern.

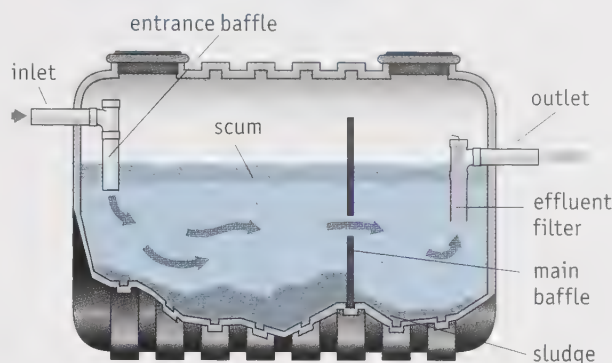
Most sewage-treatment systems consist of at least two major components: the septic tank and the absorption (or leaching) area. Sometimes additional components are added in an effort to hasten and/or improve treatment, but the tank and absorption area are usually there in one form or another, the size of both typically determined by the number of bedrooms in the dwelling, the number of people living there, soil conditions, or some combination of these variables.

In a properly designed system (a necessary qualifying phrase), first stop for the effluent once it leaves the building is an approved septic tank (the tank usually stamped with a CSA, NSF, or appropriate governing body symbol and approval number). The tank has two primary functions: to serve as a temporary storage bin for some of the stuff you send down the drain, allowing it to settle and separate, and to operate as a cafeteria for anaerobic bacteria. These microscopic epicures eschew oxygen but chew sewage – assisting in its decomposition – and then they die. (Not surprising with a diet like that.)

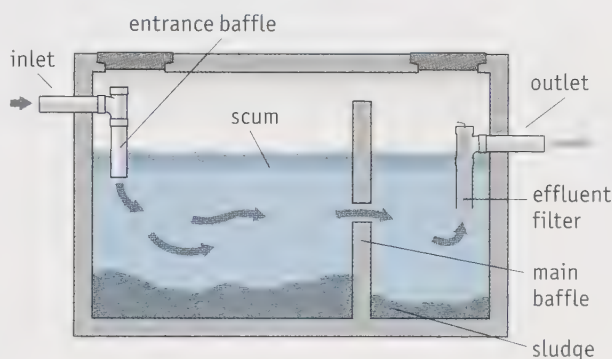
These bacteria and their corpses become part of the fluids in the tank and, ideally, it's only those fluids we want venturing out of the tank into the absorption area.

As with any popular cafeteria, interior design plays an important role in the tank's success. Upon entering the tank, the first thing to greet poo patrons is a small entrance baffle. It's there

PLASTIC SEPTIC TANK



CONCRETE SEPTIC TANK



Tank theory:

Concrete and plastic are generally the preferred materials for septic tanks.

Inside, baffles slow the flow so sewage solids (sludge) sink to the bottom while greases and fats (scum) rise to the top.

to slow the speed of incoming sewage. The main dining area is usually divided into two chambers by a wall that at first glance bears some visual similarities to the ubiquitous office divider, only with holes punched through its midsection. This wall has two functions: One is to work as a baffle, slowing the flow to allow sewage solids to sink to the bottom (where they are christened "sludge") and greases and fats to float to the top (to acquire the title "scum"), leaving a turbid liquid in the middle. The wall's second function is to keep as much of the sludge as possible in that initial chamber so the sewage flowing into the second chamber (through the wall's holes) is more liq-

TANK MATERIALS

The majority of modern septic tanks are prefabricated, made from concrete, fibreglass, or plastic. Steel is permitted in some areas but, generally, concrete or plastic is preferred. Some jurisdictions will permit poured-in-place concrete or concrete-filled, steel reinforced concrete block. Although a skilled tradesman can in theory build a higher-quality tank than most off-the-rack vendors can provide, the prefab route is much easier (and usually less expensive) if you're doing it on your own. Plastic (HDPE) has the advantage of being very light, making it easier to handle in tight areas and easier to transport to sites referred to by tradespeople as "inaccessible" when they're already busy with easier jobs. Plastic tanks can even be floated to the site. Fibreglass tanks can be floated too, but are a little heavier and more fragile, requiring considerable care during installation. Concrete tanks are usually less expensive than either plastic or fibreglass types and much less likely to being punctured during installation. (Puncture a fibreglass or plastic tank and it's junk.) However, a concrete tank must be delivered and lowered into place by a crane-equipped truck, making it unsuitable for many remote locations.

liquid in content than sludge or scum. At the tank's exit, another small baffle – and increasingly, an effluent filter – work to allow only the turbid liquid out, keeping the sludge and scum trapped inside the tank. The larger the tank, the slower the rush to get out, allowing more time for the solids to separate into sludge and scum. While all this may sound a bit analogous to certain governmental systems, there are some important differences. For example, with a properly maintained septic system, the sludge and scum are held in the tank before getting pumped out every couple of years, leaving the space open for new sewage. No excrement gets re-elected. Take a pass on this pump-out, however, or skimp on the tank size, and sure as shootin' the sludge and scum will cause the ruination of any system, no matter how good it may have been at the beginning.

In a properly designed and maintained septic tank, the sludge settles to the bottom and the baffles keep the scum floating above. Meanwhile, the odorous liquid sandwiched in between runs out the tank's exit and into the absorption area.

To help ensure that it's only liquid exiting, many jurisdictions insist that an effluent filter be

installed at the tank's T-junction exit. Even when not required by law, you want the filter, whether installing a new tank or retrofitting an old one. The filter, about 3"–4" (8–10 cm) in diameter and 18"–22" (46–56 cm) high, keeps the majority of free floaters roughly $\frac{1}{16}$ " (1.6 mm) or bigger in the tank waiting for the pump-out truck, rather than in the absorption area where they can clog pipes – thus extending the life of the system. Yes, the filters will clog too but, in contrast with the absorption area, these guys are easily removed to be cleaned or replaced. Some even have an optional alarm to let you know when they need cleaning.

The absorption area is responsible for dispersing the tank's escapees. Traditional absorption areas – a.k.a. the leaching, seepage, or tile bed – only work as intended when there's enough room for proper dispersal and the permeability of the soil meets acceptable levels. Permeability is determined by a percolation test. Approved methods for this vary (though they all tend to yield the same results), so again, check with the sewage police for details. (For percolation-test basics, see Chapter 10.)

THE LEACHING BED

By far the most prevalent type of effluent-dispersal mechanism for private sewage systems is the leaching bed. The bed is a dedicated area on your property that facilitates the seepage of effluent from the tank into the soil in a (theoretically) controlled fashion. It's here that aerobic bacteria dispense with nasty pathogens and the like.

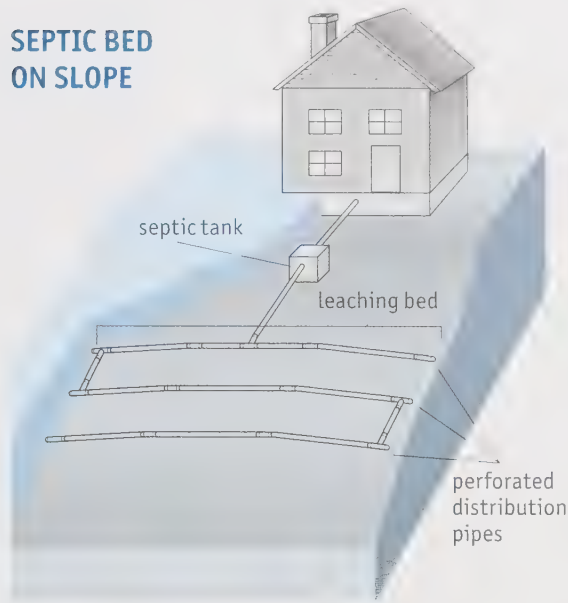
To visualize what a traditional bed is supposed to look like under the soil, picture a giant pitchfork buried in the bed: The handle represents the pipe connecting the tank to the bed; the horizontal rod to which the tines are attached is the bed's 3" or 4" diameter header pipe; and the tines are the 3" or 4" diameter distribution pipes through which the liquid sewage passes. Where the "handle" meets the header, a distribution box is often installed to encourage equal volumes of effluent to flow through each of the distribution

pipes (sometimes not necessary when the header feeds an even number of distribution pipes). This picnic-basket-sized box (usually made from concrete or plastic) has holes punched in the sides for individual leads to each distribution pipe, the holes being at slightly different levels. With either method, the ends of the distribution pipes may be capped, or joined together by a non-perforated cross-pipe.

Years ago, distribution pipes (or runs) consisted of several 12" (30 cm) clay tiles carefully placed with narrow gaps between them. Now, lengths of perforated plastic pipe are glued together, or sections of plastic upside-down-U-shaped or semi-circular louvered channels (sometimes referred to as chambers) are snapped together to form the runs. Through the gaps in the tiles or holes in the pipes the sewage oozes out into an envelope of $\frac{3}{4}$ " stones (local codes may not require the gravel for louvered channels). From there, the sewage seeps into the soil where bacteria and bacterial leftovers from the anaerobic cafeteria are gobbled up by aerobic bacteria. (These bacteria like oxygen.)

No matter what distribution system is used, the type of bed it rests in is nearly universal. Parallel trenches approximately 2' (0.6 m) wide are dug in the existing soil about 5'–6' (1.5–1.8 m) apart. To take advantage of the aerobic bacteria naturally occurring in the upper layers of the soil, the depth of the trenches generally do not exceed 2'–3' (0.6–1 m). Each run is placed in the trenches, surrounded by an envelope of gravel, if required, and then topped off with soil. Perforated pipes are first covered with a blanket of building paper or geotextile fabric. Channel or chamber systems don't require the blanket or the gravel. Because the effluent is supposed to seep into the soil, not pour out onto it, the pipes or channels are set level, or at a maximum slope of 2" over 30' (5 cm over 10 m). (Check local requirements.) The blanket keeps the upper layer of soil from washing into the gravel and plugging the gaps, or holes in the distribution runs. It's a simple and relatively inexpensive filtration system to install, suitable for level sites with soil that meets acceptable percolation standards.

SEPTIC BED ON SLOPE



Sloping septs:
For sites that aren't level, the distribution pipes and surrounding aggregate are laid in slalom-like trenches, with each successive trench set lower on the slope than the one above.

ABSORPTION AREAS FOR SLOPING SITES

For sites that aren't level, absorption trenches can be installed to run perpendicular to the slope of the land, each successive trench set lower on the slope than the preceding one. This type of bed is a bit like a slalom ski run for bacteria and other microbes, or maybe one of those giant water slides seen at finer amusement parks everywhere. To picture what lies underground, scrap the pitchfork imagery since the pipe from the tank connects directly to the first distribution pipe at its centre point and perpendicular to it. One end of this distribution run is capped, the opposite end being connected to a non-perforated cross-over pipe that feeds the next distribution run down. The effluent travels the full length of that run before meeting another cross-over to the next run and so on, the final run being capped at the end.

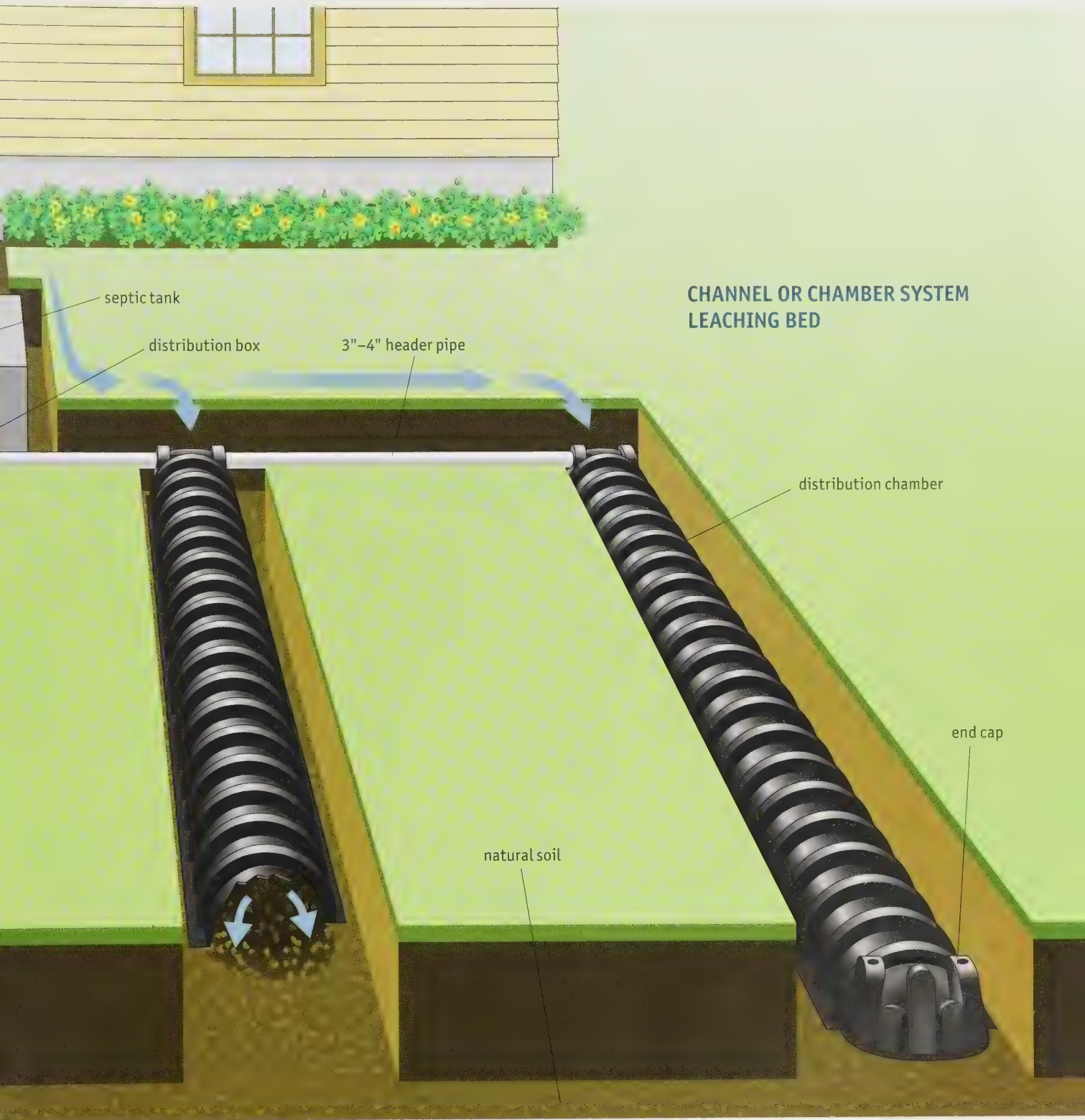
THE RAISED BED

When faced with soils with high clay content, bedrock just below the surface, and high water tables, it's normal to flunk the percolation test. One solution is to "import soil", a euphemism for having sand trucked in and piled up on your property to make what is known as a "raised



Septic bed with perforated plastic pipe:

The first stop for the sewage is the septic tank, where solids settle and grease rises. The remainder – a turbid liquid – then moves to the leaching bed. Traditional beds (above) use a series of perforated distribution pipe runs set in trenches and surrounded by gravel. Building paper (or geotextile fabric) and soil cover the runs.



Septic bed with plastic channels or chambers:

In this style of leaching bed, once the septic tank has done its work, the effluent is directed through a series of semi-circular or U-shaped chambers that snap together to form the runs. Because the channels keep soil from washing down and plugging the system, gravel and building paper (or geotextile fabric) are not required.

bed". Depending on the ability of the existing soil to absorb liquid (clay being about the worst), 3' (1 m) or more of this imported soil may be required before the distribution system can be laid out over the sand and subsequently covered with more sand, and a skim layer of topsoil.

Because the bottom of a raised bed usually rests on an impermeable surface such as rock or clay, an additional mantle of imported sand is sometimes required at the end of the bed. Without a mantle, when the sewage reaches the rock or clay, it simply runs along the surface and out onto open ground. The mantle, a layer of approved soil approximately 50' (15 m) long by 10" (25 cm) deep, helps contain the effluent below surface for a longer period, affording it further opportunity to slowly seep into less-permeable soils, rid itself of pathogens, and for its nutrients to be used up by whatever vegetation is growing on the mantle.

A variation of the raised bed is the treatment mound. Here, the distribution runs are set in a single, large bed of gravel (picture several hotdogs in one big bun), then covered with soil like a standard bed.

sewage will need to be pumped up to the bed. (The effluent is always pumped up to a treatment mound.) Any levels of the dwelling that are above the bed can still use gravity-fed plumbing, while an individual sewage lift pump can serve the fixtures or appliances below bed height. Some toilets, such as the Saniplus, have built-in lift pumps that can handle an entire bathroom's worth of waste water; or a separate pump for grey water fixtures, like sinks and showers, can be installed, usually in a sewage well (also known as a pump chamber). This well is a small, sealed holding tank, about 5–10 US gal. (20–40 L) in capacity, the pump inside being activated by a float. It works much the same way as does a sump pump in a suburban basement, and is usually located inside the house close to the source of sewage in need of a lift.

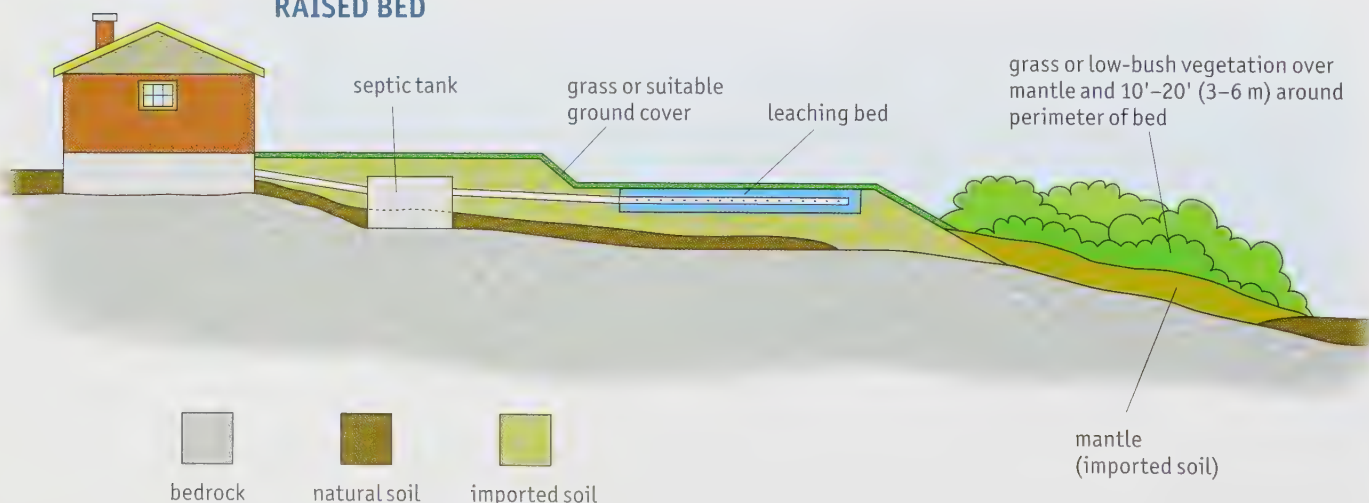
If the entire plumbing system needs a lift, a sewage pump would then be required to push the sewage uphill to the septic tank, the absorption area, or holding tank, depending upon site requirements. This type of pump is similar in concept to a centrifugal water pump but designed more for volume than pressure, our main goal here being to get the quantities of effluent out for treatment rather than enjoy a good shower in the stuff. A sewage pump is designed to handle liquid and sewage-style solids. It can be located in the house but is usually submerged in the septic tank or a sewage well. (And you thought servicing the water pump was a distasteful job.)

An imported bed:
If your soil flunks the percolation test, you'll need to have suitable soil brought in to create a raised bed. In areas with very poor natural absorption, an extra mantle of this soil is usually required at the end of the bed to keep the sewage from running out along the surface.

NEED A LIFT?

Should the septic tank or distribution system in a raised bed end up being higher than the toilet, kitchen sink, or other source of sewage, the

RAISED BED



WHERE TO PUT THE SEPTIC SYSTEM

Septic tanks and absorption areas both have minimum legal requirements for setbacks from buildings, lot lines, open water, and wells. The accompanying chart (p. 117) gives most of the preferred minimum setbacks, but check with the sewage police for any anomalies that may apply to your particular jurisdiction. These folks will also be able to supply you with all the technical poop and pertinent regulations governing the size of the tank and absorption area, and the particulars regarding your choice of distribution system.

If a raised bed is used, applicable setbacks should be increased by at least 2' (0.6 m) for every 1' (0.3 m) of added height.

REDUCING THE SYSTEM'S FOOTPRINT

The topography that often attracts us to rural settings – rock outcrops, steep slopes, nearby water – can work against us when it comes time to squeeze a septic system onto the property, or update an existing one. Sometimes, the legal minimum clearances for a trench-type absorption area cannot be realized. Fortunately, there are alternative septic systems for tight quarters, tons of them, actually, with “new and improved” ones hitting the market almost as often as effluent hits the toilet. (Or so it seems at times.) Some systems even claim that the effluent exiting their system is so pure that it can be dumped right out onto the ground. True, a few areas do permit such direct discharge practices, but for most jurisdictions, the effluent emitted from these systems is still considered sewage, and therefore in need of further treatment, a stance this book shares. The good news is that many of these alternative systems do a more thorough job, typically by providing the sewage more contact time with anaerobic bacteria, which is how the majority of them manage to reduce the amount of real estate required. The majority also require more maintenance, which in turn demands more from sys-

tem owners, both in long-term cost and in owner involvement. Warranties for manufactured systems tend to be significantly less than the system's advertised life expectancy, and the wording of some can give the manufacturer an easy out should problems arise. As with everything in life, read the fine print before signing up.

To help sort through the mélange of methods available for dealing with the stuff we send down our drains, I've divided all alternative systems into two very broad categories, tank solutions and absorption area solutions, with smaller sub-categories within each division. (Note: In some cases, the category names are of my creation, so don't be surprised if those in the trade don't recognize them.)

TANK SOLUTIONS

A blanket for bacteria

The bacteria working to break down the sewage in your tank start to get lazy as the temperature dips below 60° F (15° C), and then hit the snooze button at about 40° F (5° C), none of which is good news for the absorption area. Regardless of type of tank or septic system, the answer is to insulate, just as we might put on a sweater to keep warm in chilly weather.

For an existing buried tank, remove the soil above it. Should the tank be plastic or fibreglass, level the soil even with the apex of the curved top, being careful not to puncture the tank. Concrete tanks can be swept clean. With the soil pushed aside, construct a couple of boxes around the septic tank access hatches. This makes it easier for the pumper-truck operator to locate the hatches without digging holes in your yard. The boxes should be just big enough to allow the hatches to open easily. Depending on the depth of soil covering the tank, the boxes (picture a bottomless planter-box) can be made from concrete blocks or even a suitable wood, such as fir or the pressure-treated stuff. If not into building your own hatch extensions, some tank manufacturers offer prefab risers, in either plastic or concrete to match the tank material.

Next, place 2" thick Styrofoam SM (the blue stuff rated for 30 psi) over the top of the tank (leaving the access hatch boxes uninsulated for the moment), extending the coverage a couple of feet beyond the perimeter of the tank to prevent the cold from doing an end-run. Then cut separate pieces of SM to fit snugly inside the access hatch boxes, while still allowing for easy removal of the foam come pump-out time. Replace the soil over the rest of the tank and re-plant grass or some other ground cover. A concrete patio slab makes a good cover for the hatch.

For new installations, insulate the same as above before the covering the tank with soil.

For folks with above-ground tanks, build a shed around the tank, insuring that the shed is adequately vented to prevent the build-up of methane gas. I'd suggest 2" x 4" or 2" x 6" construction with a shed roof for simplicity, placing insulating batts between the studs as you would in standard house or cottage construction (you may need a building permit from local authorities). Finish the shed off with the siding of your choice, and add an outhouse-style quarter moon to the access door for fun.

Holding tanks

From an owner's standpoint, the holding tank works just like a standard tank-and-bed system except that now, nothing leaves the tank. There is little treatment of the sewage and no onsite absorption area. When the tank is full (which will happen much more frequently than a tank-and-bed system), the sewage must be pumped out. Some municipalities are reluctant to approve holding tanks since the sewage is usually trucked to a local treatment facility which may already be operating at or near capacity. Others will only approve a holding tank if the owner can provide proof of an approved method of disposal, which usually means a signed contract with a certified hauler of sewage. However, some jurisdictions, such as Saskatchewan, require that any dwelling located within 1,500' (450 m) of the high-water mark of any surface water shared with an urban municipality or recreational area must use

a holding tank. Holding tanks are also used extensively in areas that experience extreme winter temperatures, such as Alaska and the Canadian far north, as absorption areas in such climates are almost certain to freeze come winter. And a holding tank is sometimes the only sewage-system alternative in locations where no space exists for an absorption area, or the slope of the land exceeds what is permitted locally for contour-style absorption trenches.

Every holding tank must be equipped with an alarm to alert owners of impending pump-outs which, depending on use and frequency, can get expensive.

Aerobic systems

An aerobic system uses a modified septic tank in which air is introduced into the sewage, thereby encouraging aerobic bacteria to take up residence. Aerobic sewage eaters are faster and hungrier than their anaerobic pals, consuming more sludge, so the sewage gets broken down more efficiently before making its run out to the absorption area. Because this less-viscous liquid requires less filtering, some jurisdictions allow the absorption area to be reduced to as much as two-thirds of that required for a bed fed by a standard (anaerobic) septic tank.

Tanks for aerobic systems are divided into two or more chambers, the initial chamber typically allowing for incoming sewage to settle and separate into the usual turbid liquid sandwiched between layers of sludge and scum, much as it does in a standard septic tank. It's in the next chamber that the sewage generally gets aerated. The methods of introducing air into the sewage vary greatly, but normally involve some form of revolving motor-driven stir discs or sticks (sewage coming into contact with the air above, much in the same manner as when you stir hot soup to cool it), or a pump that forces air down into the sewage (much in the same way you can make a chocolate milkshake bubble by blowing through a straw). Many require add-ons such as sewage pumps, filters, electronic control panels, and computers wired to head office to function,

and nearly all demand more frequent pump-outs than the standard septic tank, the frequency for a few approaching that of a holding tank.

One problem common to all aerobic systems is the difficulty of getting the correct percentage of air into the sewage. The more sewage you put into it, the more air it needs to work as designed. The system doesn't know that you had a big weekend party, with tons of food and drink, much of which got digested and then later deposited into your septic system; it just keeps mixing in the same amount of air all the time. Yet when the percentage of air is either too high or too low, efficiency suffers, reducing the rate of decomposition. This in turn puts the absorption area at risk. Speaking of parties, another problem is the sudden, unexpected load. This is not good for any septic system, but when it happens to one with a reduced absorption area, the risk of system failure increases.

While more efficient treatment of sewage is a praiseworthy goal, the complexity of many aerobic systems has led to spotty reliability for some. And when you include added costs due to frequent servicing to change filters, maintain the moving bits, and monitor efficiency – and the need for electricity – things can get expensive. But if you have few other options because of limited space and/or local regulations, look for the system with the least number of moving parts, and the least amount of maintenance and operating costs. Finally, you need to know how often the aerobic system's tank needs to be pumped out compared to a standard septic tank.

ABSORPTION AREA SOLUTIONS

Seepage pits

In principle, the seepage pit (also known as a leaching pit in some parts of the sewage world) serves the same purpose as the leaching bed. However, instead of a leaching bed's group of absorption trenches, the seepage pit has one or more chambers constructed in gravel-lined pits. The chambers are usually built on site from un-

cemented stone, brick, or concrete block. (Standard 8" or 12" concrete blocks are sometimes laid on their sides to take advantage of the large holes running through them.) The gaps and holes in the pit wall serve the same function as the holes in plastic pipe or the louvers in plastic channels in a leaching bed. If more than one pit is required to handle the quantities of sewage, the flow of effluent to each pit must be equal just as the flow must be equal through the distribution runs in a leaching bed. Therefore, the pipe exiting the septic tank has to branch out to each pit individually, just as it's distributed in the leaching bed. The sewage cannot first flow to one pit and then the next.

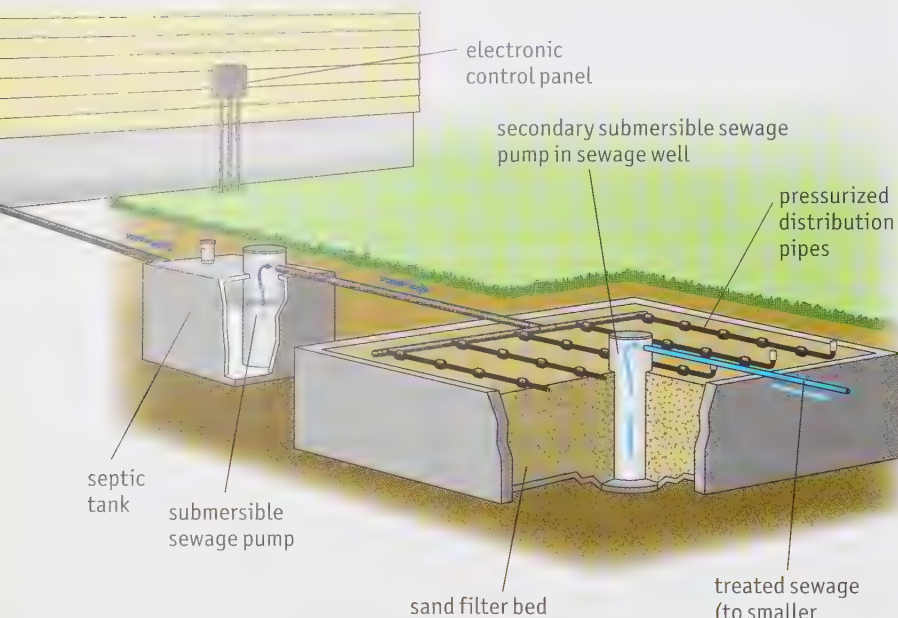
In design, the seepage pit is very much like a grey water leaching pit and the type of cesspool occasionally approved to handle composting-toilet overflow and /or urine. Although seepage pits were once quite prevalent in some parts of North America, they rarely see action now due to their inability to handle the loads of a modern whole-house or whole-cottage sewage system.

Enhanced filtration

All of the following systems increase complexity, which in turn increases maintenance and, usually, the up-front costs too. This is not necessarily a bad thing, as long you are aware of what you're getting into before getting into it. Some disperse the effluent over the absorption material in timed cycles, which in theory – and probably in practice – provides the material time to process each dose before getting hit with the next. Also, in many cases it may be possible to install one of the following options on top of an existing failed or marginal leaching bed, reusing that bed as the final absorption area for a now much cleaner effluent. As with conventional absorption areas, the life expectancy of all of these systems will be enhanced by installing an effluent filter at the exit port of the septic tank.

The common goal with all these systems is the quest for increased contact time between aerobic bacteria and the effluent – the greater the contact time, the more efficient the treat-

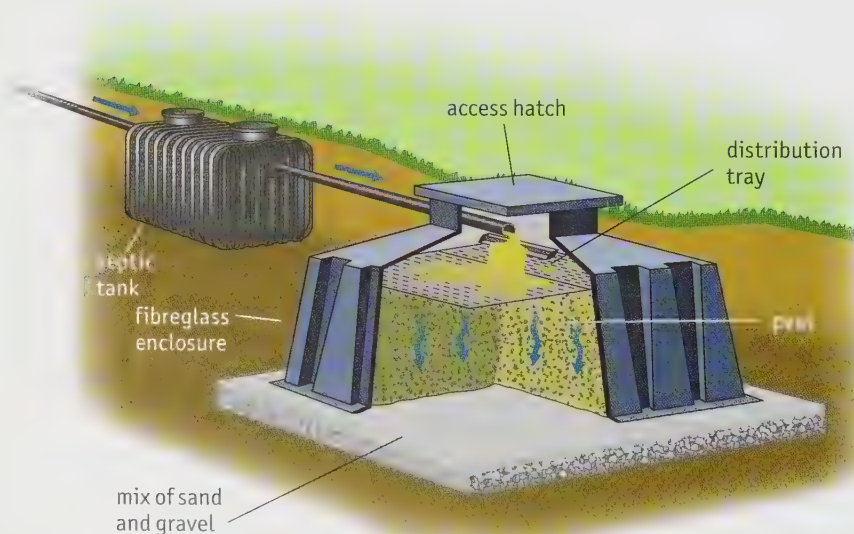
TYPICAL INTERMITTENT SAND FILTER



Like a trip to the beach:

Intermittent sand filters disperse liquid effluent through a series of pipes sitting above a bed of sand and gravel, the whole works enclosed in a waterproof membrane. After percolation, collected liquids head to a small conventional bed.

TYPICAL GRAVITY-FED PEAT SYSTEM WITH FIBREGLASS ENCLOSURE



Getting the peat treatment:

The open structure and natural acidity of peat make it friendly to aerobic bacteria and hostile to pathogens. Post peat, effluent moves into a leaching area for final treatment. Peat systems work best when flow is restricted or delivered in cycles.

ment process. This is usually achieved by providing more surface area for the two to meet, and for more air to circulate in order to maintain a healthy environment for those air-loving aerobic bacteria. Some of these systems also reduce nitrogen and phosphorous, but again, not without increasing complexity.

Filter bed

What differentiates a filter bed from the traditional leaching bed is that it uses sand that meets specific granular size requirements. (Grains that are too small don't allow room for oxygen, aerobic bacteria thus getting replaced by the anaerobic guys. Grains that are too big allow effluent to flow through them too quickly for treatment.) As in the treatment mound, the pipes are laid in a continuous layer of gravel, rather than in individual trenches. Material costs are greater, but the size of the bed can be reduced by a third to a half that of a conventional bed, and maintenance costs are no greater than those of a conventional system. (Clearances for filter beds remain the same as those for conventional septic systems, as does the frequency of pump-outs.)

Another approach to enhanced filtration is to introduce a tertiary system, giving the sewage a bonus bout of treatment before it heads to a final absorption area that is much reduced in size.

Intermittent sand filter

With an intermittent sand filter, variations from the norm begin at the septic tank, which is now a single compartment, though no smaller overall. Baffles aren't required to slow sewage flow, that duty now handled by a "vault" housing an effluent filter and submersible sewage pump. The sludge remains in the tank (which, as always, is pumped out as needed), with only the liquid pumped on to an absorption area, which is enclosed in a waterproof membrane. A series of $\frac{3}{4}$ " pipes intermittently disperse the liquid (through $\frac{1}{8}$ " holes) over a 3' (1 m) bed of sand sandwiched between two layers of gravel. In common with all systems, the effluent percolates through the

absorption media as aerobic microbes feast on it. But, unlike the systems discussed so far, the effluent seeping through the sand collects at the bottom of the waterproof membrane and from there is either periodically pumped to a conventional absorption area or, where possible, gets there via gravity.

The filters and dispersal pipes need cleaning annually or semi-annually depending on use and company policy, and electricity is required to operate the pump, the electronic control panel, and pressurize the dispersal pipes.

A recirculating sand filter operates in much the same manner except that the effluent is recirculated through the sand filter a few times before leaving for a conventional absorption area.

Peat

Peat is dark-brown, partly decomposed vegetation found in moist, acidic environments, such as bogs. Peat is an excellent filter and, thanks to its open structure, makes a good home for aerobic bacteria. And, bonus, its acidic nature works to help kill pathogens. But because its contents vary, its consistency also varies, more than other filter media. Therefore, peat works best when the input flow is restricted, either by quantity or frequency (as when delivered in cycles).

Peat systems can be housed under a roof, such as in a fibreglass hut, either above or below ground, the effluent either draining out an open bottom into a gravel leaching area for further treatment or, when the container has an enclosed bottom, the treated effluent contained, with drainage pipes typically delivering it to a traditional absorption area, one that's reduced in size, for final treatment. In another variant (and there are lots of them), the peat is contained in an open bed, the filtered effluent collecting on the bottom of the enclosure where drainage pipes take it either to a small absorption area, or an artificial, enclosed, gravel-based wetland (more on this later), and from there, the treated effluent seeps out into mantle of sand.

All good so far, but peat's efficiency is also its nemesis, for it doesn't last as long as a tradi-

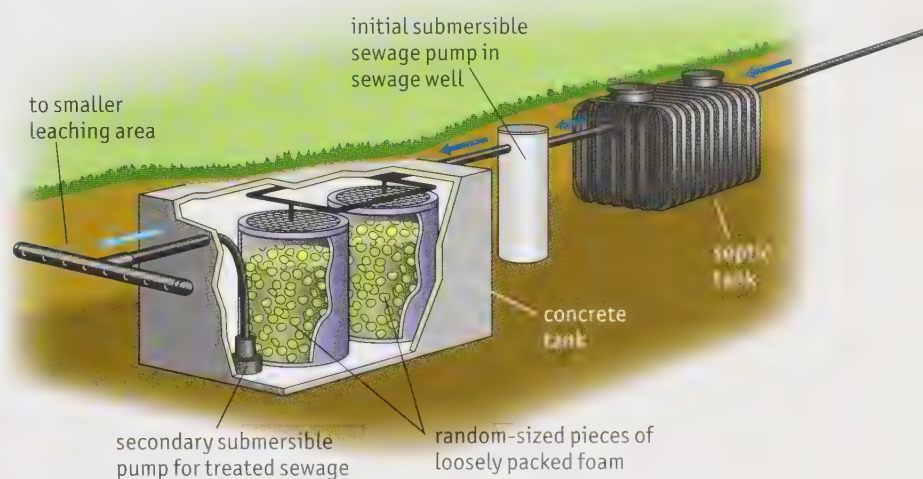
tional sand leaching bed. The advertised life expectancy is somewhere between 7–10 years, depending on the system's manufacturer, but it can be less. And in some areas, getting rid of the stuff can be very difficult, local landfill and traditional disposal outlets unwilling to take it.

One odd claim made by some manufacturers of such systems is that peat does not freeze. True, but neither does sand, foam, or fabric. But sewage does and we're pouring it in there, so the claim is pointless.

Synthetic media

Synthetics possess the greatest promise for efficient sewage treatment because of the flexibility and control they offer from a design standpoint. Synthetics can be any one, or combination, of a million different plastics, coming in at least as

TYPICAL BIOFILTER WITH SYNTHETIC FOAM MEDIA



Synthetics and sewage:

Whether they're shaped into fabric, netting, webbing or foamed into sponge (above), synthetic filter media perform the same basic chore as sand or peat, but offer more flexibility in system design. Periodic cleaning is required.

many shapes, sizes, and permutations. For instance, synthetic materials can be spun into sheets of fabric or netting, moulded into webbing, foamed into sponge, or made into rubber duckies I suppose. Most manufacturers hide their medium's identity beneath a heavy cloak of

brochure blather designed to impress by confusion. Typically, the chosen medium can be layered, stacked, or simply tossed into a tank-like enclosure, the goal again being to create the greatest surface-area to sewage-volume ratio. Many incorporate variations of the methods discussed above, including cycled-release of the effluent and forced-air circulation via a fan. And admittedly, the effluent emitted from many is often the least contaminated of all the other manufactured systems. But, despite certain claims, it's still not drinking water.

In common with all effluent absorption media, any synthetic media will eventually need to be replaced, though for some, this could be twenty or more years down the road. But whenever it happens, the problem facing the owner will be disposal – who's going to take this dung-laden stuff? Get acceptable answers, in writing, from the manufacturer before choosing any system.

Wetlands

It seems appropriate to end this examination of absorption areas with nature's own treatment system, the wetland, a.k.a. swamp, marsh, everglade – you know, those supposed wastelands we continually fill in for some future housing or industrial development? The wetland is nature's water purification system, home to a huge variety of nutrient-hungry plants such as bulrushes and cattails, many of which also break down toxic wastes into less harmful substances. So if we truly want clean water, these are ecosystems we should be encouraging, not eliminating. (Okay, I'll step off the soapbox now and get back to private sewage absorption areas.) Because a wetland's performance is largely out of our control, its efficiency is variable, even with constructed artificial versions. But a wetland works extremely well as a final wastewater treatment system after that waste has passed through any one of the above systems. Typically, the plants are set in a shallow bed of gravel, the bottom of the wetland lined with a waterproof membrane. This stops the incoming liquid from dispersing into the surrounding soil until it has passed through the wet-

land, insuring maximum exposure to those nutrient-hungry plants before slowly leaching out the far end of the wetland. As the wild plants and flowers flourish, be sure to set up some chairs to watch the birds come flocking in, all thanks to your last visit to the washroom.

WHY SYSTEMS FAIL

We curse the system when it fails, hate the foul smells it emits, turn away from the puddles of brownish liquid that suddenly appear to taunt us, ignore that fact that our sewage is headed for the neighbour's yard, a well, or a waterway because good old Mother Earth will take care of it as soon as the weekend crowd leaves. Wrong. Yet still we ignore it because we know this is going to cost. Which leads to the most difficult truth to face: In most cases, it's easy to find the reason for septic system failure – we only need look in a mirror.

If the engine in your car fails because you neglected to change the engine oil, it's not the car's fault. Nor should the government be expected to "Do something about this mess." Same sort of thing applies to the septic system except, of course, that it's not likely you're going to trade it in on a new one every few years. The traditional tank and leaching bed system is the most abuser-friendly and least demanding of all systems, yet it's the one that gets a bad rap, often referred to in alternative-system brochures and literature as the "troublesome septic system." But if we can't look after the simplest, least-demanding system, how are we ever going to keep a more complicated and needy system working as originally intended?

So which system is the least likely to fail? It's not the type of system so much as its condition. Odds are, the best system is the one that is both new and properly maintained. That said, any system will eventually fail. For instance, the lifespan of a traditional absorption area used year-round is estimated to be 15–20 years, while a system subjected only to seasonal use would in theory last longer. Sadly, the effluent flowing out from even a properly maintained septic tank carries some

sludge through the exit pipe with it (though substantially less when an effluent filter is installed). The turbidity in this effluent tends to separate out at its earliest convenience, which in a new leaching bed corresponds to the first 3' (1 m) or so of perforated pipe or channel. The sludge coagulates in the surrounding sand and gravel, forming a slimy film, called a biomat, that plugs the distribution system's holes. Over the years, the flow of sludge slowly moves down through the leaching bed, gradually plugging up things along the way. When the effluent can no longer find speedy access to the surrounding soil, it will pond.

Ponding is a pleasant way of saying that liquid sewage is coming to the surface. Ponding pushes the oxygen out of the bed, and hence the aerobic bacteria die. When this happens – even if just once – the system is no longer capable of doing what it was designed to do. This process of self-destruction is greatly hastened by a failure to pump out the tank regularly. That's because as solids build up in the tank, there is less space for incoming sewage; and therefore less time for sludge and scum to settle out before seeping out into the absorption area. Robbed of this opportunity, the sewage will quickly plug the bed and destroy it. And clogged distribution pipes are more likely to freeze, which means more ponding. Also, gases given off by sewage left in the tank for long periods of time will deteriorate tank walls and baffles, which in turn allow the sewage to run straight through to the absorption area and your yard. Regardless of cause, when the absorption area or tank is kaput, your only recourse is to bite the bullet and have one or both replaced.

REGULAR PUMP-OUTS ARE THE KEY

Due to their owner's ignorance, forgetfulness, stubbornness, false economy, or whatever other rationalization or excuse, septic tanks are rarely pumped out when they need to be. It may be helpful to think of the septic tank as a large flow-through chamber pot: you still have to empty it, but because of its size and design, not quite as often. On average, a tank should be pumped out

SUGGESTED MINIMUM SETBACKS AND CLEARANCES

FOR TRADITIONAL TANK AND ABSORPTION AREAS

(Check with local authorities for approval; setback reductions may be possible for alternative systems, or increased if percolation time is greater than 10 minutes.)

ABSORPTION AREA SETBACKS

Bottom of absorption area to high groundwater table	3' (0.9 m)
Open water or spring (including cistern or reservoir)	100' (30 m)
Wetland	50' (15 m)
Drilled well with watertight casing 20' (6 m) deep	50' (15 m)
Dug or driven well	100' (30 m)
Pump intake (suction) line	100' (30 m)
Dwelling, pool, or hot tub	20' (6 m)
Driveway	10' (3 m)
Property line	10' (3 m)
Distance from slopes greater than 25%, including cliffs or rock faces	25' (8 m)

TANK SETBACKS

Open water, spring, wetland, or well (including cistern or reservoir)	50' (15 m)
Pump intake (suction) line	50' (15 m)
Dwelling, pool, or hot tub	5' (1.5 m)
Property line	10' (3 m)
Distance from slopes greater than 25%, including cliffs or rock faces	15' (5 m)

about once every three years – more often if the system is old or undersized for the load. The best time for a pump-out is early summer after the high groundwater levels of spring have subsided. This gives the entire summer and autumn for the bacterial action to re-establish itself. (Bacteria, like most of us, prefer warmer weather.) Emptying any sewage tank (septic or holding) in the fall may not allow enough time for decomposition to

begin in earnest before winter's coldest temperatures take hold, increasing the risk of freezing, which not only stops the treatment process but could also seriously damage the tank.

Even if a pumped-out septic tank sneaks through the winter without turning into a poopsicle, it may still encounter problems if serving a cottage. Because cottage contributions to a tank's contents are usually minimal in the off-season, an empty tank in the fall is still an empty or near-empty tank in the spring. Buoyed by water-soaked soil, the tank may float and could actually pop out of the ground (the lighter plastic tanks being more susceptible to this surprise), which explains why early spring is also not a good choice for a pump-out.

Some jurisdictions have, or are considering, legislation to enforce regular clean-outs and inspections. An inspection is the only way to determine if the need for a pump-out is imminent, and a licensed contractor is the best person to carry out this task. Most jurisdictions advise against owner-operator trips to the inside of a tank because every year, some unsuspecting handyperson succumbs to the gases of his or her own effluent. Only anaerobic bacteria find honour in death by the septic tank.

A pump-out is not an expensive luxury, usually less than what you would pay for sewage taxes in most cities. But too many folks call the "honey wagon" only after things start to smell or the ground gets soggy over the absorption area. By then, it's too late; your system's shot. And contrary to the hyperbole of some advertising, no amount of additives can save it.

THE ISSUE OF SEPTIC ADDITIVES

The common element of these "miracle" septic savers is the assertion that the product will keep your system trouble-free and odour-free, or words to that effect. Some even leave no question in the consumer's mind that the product in question will stop the pumper truck. Maybe, if you pour the stuff into the truck's fuel tank rather than your septic tank.

Every jurisdiction in North America contacted regarding these additives advises against their use, but faced with a failed system, desperate hopefuls continue to pour this stuff, and their money, down the drain. Most of the products do activate bacterial growth in the tank, as claimed. But according to all the biologists I contacted, simply adding more sewage does the same thing. Any product that claims to do more – such as unclog pipes for instance – could be in the hazardous-chemical category, and should definitely not go into any septic system because you can bet your long-term disability fund that it too will eventually end up in the water supply.

Another "additive" I became aware of when installing my first new system, one that seems to have some history behind it judging from the age of the person espousing its virtues, is a dead rodent. "Shoot two squirrels and dump 'em into the tank before you use it," I was advised. "Gets the bugs working." I asked whether substituting a single porcupine would work as well, seeing how these pesky varmints had recently mistaken my cabin for a meal plan, but the elderly sage replied that no, "Squirrels are better 'cause you can flush them down the loo." Now I haven't been able to find any scientific evidence to substantiate this claim, nor do I endorse shooting squirrels (porcupines I'll reserve judgment on for the moment) – I only mention this within the context of septic additives. However, based on roadside observation, this method does appear to have one thing in common with the additives above: I wouldn't count on a squirrel to stop a pumper truck.

Overloading the system has the same effect as not pumping it out. Many folks with high-yield wells, or who draw water directly from a lake or river, may enjoy an unlimited supply at the tap. Yet what we don't realize is that the septic system has to cope with all that incoming liquid (out of sight, out of mind), and the more liquid we feed it, the greater the likelihood we will overwhelm the system's capacity to deal with our sewage, causing the solids and anaerobic bacteria to charge out and plug the absorption area. Besides shortening the system's life, this constant flushing of the septic tank also means reduced

decomposition in the tank, which lowers the inside temperature, which in turn decreases efficiency and increases the risk of freezing in cold weather. So regardless of supply, minimize your water consumption.

HELPING THE SYSTEM

LESS WATER EQUALS LESS WORK

Traditionally, indoor toilets swallowed 5.8 US gal. (22 L) of water (among other things) per flush. Most new toilets do a better job using a mere 1.6 US gal. (6 L) per flush or less. And some have the option of using only 6.3 US pints (3 L) if it's only liquids we're flushing. As a cautionary note, from my experience most products designed to reduce consumption in existing toilets, either by using an add-on two-stage flush mechanism or via a baffle (which reduces water for every flush) don't work. Typically, neither the toilet tank nor the bowl were designed to function with less water, so many times two or more flushes are required, which ends up using more water, not less. Many water-saving techniques are free, like the wise adage, "If it's yellow, let it mellow; if it's brown, flush it down." Some can even be fun, like showering with a friend. And remember, every time you don't use water, you don't use electricity to operate the pump.

Keep the run-off from roof drains or drainage tiles away from your septic system, and don't drain hot tubs or pools into it either. Filling a dishwasher before turning it on and doing laundry throughout the week rather than all on the same day also lessen the load. And don't backflush any water treatment system into the septic tank; instead, direct it out onto the ground (see Chapter 6).

Don't build additions or add washrooms or even appliances without checking with the sewage police to ensure that your system will handle the load. It probably won't, yet many folks continue to demand more and more from a system that through natural degradation can only give less and less. In most jurisdictions, it's against the

law to enlarge or alter a dwelling if it will negatively effect the operation of the sewage system.

WHAT YOU SHOULDN'T PUT IN THE SYSTEM

Don't put paints, thinners, degreasers, old medications, and toxic cleaners down the drain. Aside from the very real danger of these products (some of which are known or suspected carcinogens) leaching out into the water table, they can also diminish the effectiveness of sewage decomposition by killing bacteria or breaking down the scum, allowing greases and solids to leach out into, and plug, the absorption area. Chlorine bleach destroys bacteria, and it doesn't care whether it's in the wash or the septic tank, so if you must use it, do so sparingly. Acids used to rid kettles, toilets, and water tanks of lime deposits can corrode plumbing and septic tanks and, worse, can leach into wells and waterways. If you have to eliminate such deposits, do it outside, and neutralize the acid afterwards with baking soda.

Ignore all tales of how coffee grounds or the products of in-sink food waste grinders are good for the system; they simply create more sludge. The products of both belong in the compost heap, not down your drains.

Do not put anything into the septic system that will not easily decompose. This includes cigarette butts, cooking fats, greases, disposable diapers, paper towels, and facial tissues. Put them in the garbage. To determine if your preferred brand of TP will decompose readily, place a few sheets in a jar half full of water. Cap the jar and shake it vigorously. If the TP breaks up into little pieces, it's suitable for septic use.

The basic guiding rule is simple: Only the stuff exiting your body (and easily breakdownable TP) should go down the toilet, and only used wash water should go down the drains.

TREAD LIGHTLY

Absorption areas are great level playing fields for croquet or badminton matches, but the only

PRIVATE SEWAGE SYSTEM TROUBLESHOOTING GUIDE

(Note: While maintenance is not only allowed but encouraged, in most jurisdictions a permit is required for any repairs or modifications to the system.)

PROBLEM	PROBABLE CAUSE/COMMENTS
SLOW FLUSH OF TOILET, OR SEWAGE BACKING UP INTO BUILDING	Pipes leading to septic or holding tank clogged: Call a plumber or rent an auger and clear out the pipe yourself. Tank full: Get it pumped out, and be thankful it wasn't the absorption area. Absorption area failure: Call the sewage police and arrange for a new one. If the area cannot be relocated to another suitable location on the lot, then digging up the old area and importing new approved fill might be required.
ODOURS	Vent stack blocked: The most likely cause of this is a bird or squirrel nest. Climb up on the roof and evict the free-loading beasts, installing a screen over the end of the vent stack, which sometimes discourages them from returning. If problems with these squatters persist, it may be necessary to fabricate a cap for the stack (similar in concept to a chimney cap). Vent stack not high enough: The top of the stack should be at least 1' (0.3 m) above the roof. If you are in an area susceptible to downdrafts, this may have to be increased. Fumes entering building directly from tank: Tank may be full and require pumping, or drain pipe traps in cottage plumbing incorrectly installed or leaking. Check that the septic tank lid is making a tight seal to the tank. It should be sitting flush (pun intended) with the top of the tank. Dirt between the lid and tank can also cause a bad seal. Wind blowing the fumes in off a ponding absorption area: Call the sewage police and arrange for a new absorption area.
SOIL WET ANYWHERE ALONG LINE FROM BUILDING TO TANK TO ABSORPTION AREA	Broken pipes leading to the tank or absorption area: Locate the leak, determine the cause of the failure and rectify it, then replace the damaged pipes and connections. The tank is overflowing: Get it pumped out. Absorption area failure: Call the sewage police and arrange for a new one. It's raining: Wait for a dry spell and check again.
SEWAGE COMING TO THE SURFACE AT A POINT AWAY FROM SEPTIC SYSTEM	System failure or improper placement of system (for example, too close to a grade or bedrock): Time for a new septic system.
SEWAGE PUMP MALFUNCTIONING	The sewage pump being a variation of the centrifugal water pump, see the pump troubleshooting guide in Chapter 3.
HOLDING TANK ALARM AND/OR LIGHT ON	The holding tank is full: Get it pumped out. There is a fault in the alarm system: Have it checked by a plumber or electrician.

vehicle that should ever cross the area is a lawn mower – and that means no lawn tractors. Keep everything from boat trailers to delivery vans away, including all motorized toys such as ATVs. The weight of vehicles can crush absorption-area pipes or knock them out of level. They can also compress the soil and snow above the pipes or pits. This reduces the natural insulation, which puts the system at risk of freezing (see Chapter 12). Speaking of freezing, snow acts as an insulator, so don't compact it with snowmobiles, skis, snowshoes, or even boots – when it's cold, stay off. Fence the absorption area off if necessary to keep innocent or deliberate trespassers away.

THE NUTRIENT NEWS

As users of septic systems, our contribution to pollution is a double-edged sword: pathogens and nutrients – each coming from the same source, each doing its own damage (see Chapter 5). Traditional septic systems were never designed to remove nutrients, nutrient overload not being widely recognized as a problem much before the 1970s. Some of the newer alternative systems can reduce the nutrient output, particularly nitrogen, but as long as we urinate and defecate, our contribution to the nutrient cycle will prevail. This is only bad news when we upset nature's nutrient balance, such as when our septic discharge overloads the environment's ability to deal with it. Anything we do that has a deleterious effect on our septic system only exacerbates the problem, increasing nutrient load in our waterways and groundwater. Fortunately, there are some simple things we can do to reduce nutrient loading from septic systems.

Number one on the list is get that darn tank pumped out! Frequent pump-outs are the single most effective way to prevent an absorption area from clogging, extending the life of the area, which in turn allows the nutrients more opportunity to be taken up into vegetation before reaching the waterways. It may be the most important thing you can do as a cottager or ruralist to protect your environment, investment, and family. Use phosphate-free cleaners. Soaps

and detergents with phosphate are one source of phosphorous, the nutrient most waterways are in short supply of, the one needed for aquatic plant life to begin flourishing, which starts the eutrophication process that leads to dead lakes, rivers, and ponds (see Chapter 5 again). Keep the clearing of your lot to an absolute minimum. The more trees and vegetation that you have between your septic system and nearby waterways, the more likely nutrients are going to be taken up in land-based biosystems rather than exported into the water.

A healthy lawn or ground cover is important over the absorption area, but don't fertilize it – let the septic system do it. Minimal watering, or none, and plenty of sunshine are all that's needed. For those who pride themselves in a well-manicured yard, a vegetation buffer doesn't have to resemble untamed bush. Plant shrubs and trim them into an impressive shape – like your favourite, and coincidentally rich, spinster aunt. The important thing is that vegetation is in place to take up the nutrients before they reach the water. Trees should be kept about 10'–20' (3–6 m) away from the perimeter of the absorption area so that roots will not damage the distribution system. Trees with intrusive root systems, such as willow and poplar, should be at least twice that distance away.

THE OWNER-OPERATOR INSPECTION

A quick walk onto your septic system's absorption area can sometimes reveal potential problems. In late summer, when lawns often turn a bit brown, the nutrients leaching out into the distribution trenches cause the grass above them to grow green. If this occurs within the first few feet of a leaching area, chances are that it's functioning correctly, the sewage percolating into the soil unrestricted.

But if that green doesn't begin in earnest until the end of the bed, it's possible that the flow has become restricted, and instead of seeping out as soon as it reaches the absorption area, the full length of the trenches is required to distrib-

ute it. If this is the case, get the system inspected by a licensed contractor or the sewage police. If the absorption area has any wet spots, and all around it is dry, you don't need an inspection, you need a new system.

Your nose can also help evaluate the system's state of health. Sometimes, sewage odours from vent pipes can waft over the absorption area during a downdraft. If the foul odour persists, try taking a bath. If that doesn't solve the problem, head out to the absorption area and look for ponding. If effluent is seeping to the surface, it's likely going to raise a stink.

FLUORESCEIN DYE TESTING

Fluorescein tracing dye is a greenish-yellow fluorescent dye used for such things as dyeing wool and silk, fertilizers, and – of interest to us – as a groundwater tracing dye. Toss about a teaspoon of the stuff into your toilet, flush, and then, for the next three dry days, keep a casual eye on the septic system and surrounding area, including any nearby waterfront. Should your septic system fail this test, any seepage of sewage will boldly announce its itself as it's set aglow in a bright fluorescent greenish-yellow – over the absorption area, near tanks and sewage lines, shorelines, basically anywhere your sewage surfaces. The dye is biodegradable and it disappears from view within 12–18 hours. Any septic system that has been coloured a failure needs to get repaired – a mere pump-out won't fix the problem.

But the absence of the dye surfacing doesn't guarantee that your system's okay. It simply means it's not a blatant polluter. In situations where seepage is slow and stealthy – allowing the dye to disperse into the environment before it can be detected by a diligent eye – dysfunctional systems can go undetected. Better septic system consultants not only do the fluorescein flush but also place special charcoal packets in suspect areas – water's edge, drainage ditches, that sort of thing – then return a couple of weeks later, collect the packets and, through chemical analysis of the charcoal, search for traces of dye. In this case, no dye means no leakage.

BIG TANKS ARE BETTER

When a new system is deemed necessary, in most cases one of the best things you can do is put in the biggest tank that will fit into the available space, while still getting it pumped out on a regular basis. This gives the solids more space to separate out from the sewage, resulting in less crud getting into the absorption area. And while you are at it, go for a bigger absorption area too. Without question, a bigger septic system is going to last longer and have less impact on the environment. The costs of going bigger when you're putting in a new system are substantially less than the costs of replacing a spent system. For approximately \$200 extra, I was able to install a tank double the required size at our home, and for a few dollars more, the absorption area was increased by one third, all the while maintaining at least double the minimum setbacks. And beyond the absorption bed, there's a natural wetland to help take up the nutrients. It makes both good economic and environmental sense to overbuild, and it also lessens the odds of future cottage or house add-ons overtaxing the system.

SEWAGE ENVY

Being diligent consumers, we generally have no problem spending our money on flash, such as that spiffy new vehicle that was so easy to rationalize into a necessity. Unfortunately, a septic system lacks pizzazz. And besides, it's hidden, so who's to notice how much we spent on it? So faulty systems are typically replaced only if the sewage police notice the mess and order it done. Which prompts me to offer this amazing investment opportunity, free to any clever marketer: Instead of putting hours and hours into research, and who knows how many dollars, just to come up with yet another “best” way to handle our dung, why not simply make a designer-labelled version of one of the existing ones? Just think of the status, the envy of the neighbours, when a new Max Burns Special Edition system suddenly appears on the front lawn. Nobody would even take notice of the Ferrari parked next to it.

8. THE STAND-ALONE TOILETS

Composting
toilets

Incinerating
toilets

Chemical toilets

Operating costs
and maintenance

Venting

Regulations

Brochure
braggadocio

No plumbing? No problem. Alternatives to put you on easy seat

FIRST, IT'S IMPORTANT TO define what is meant by “stand-alone toilet” (though, given the subject matter, perhaps “sit-alone” might have been a more suitable descriptive). In the context of this book, the stand-alone toilet is one that operates independently of any sewage network or system (such as city sewers or a septic system). But let's get this straight right upfront: It does not include such undesirables as crouching over a nearby log, or enduring the claustrophobic pleasures of those portable plastic potty palaces typically seen lined up for community contributions at the annual county fair. Instead, the stand-alone toilets here are all worthy of consideration as alternatives to the plumbed-in loo. The list includes the composting toilet, the urine-diverting toilet, the incinerating toilet, the chemical toilet, and – the original stand-alone – the outhouse, which is important enough to rate its own chapter.

Each of the toilets in this chapter is a variant of the traditional bowl theme. Each can handle humanity's excreta but most are not capable of

dealing with grey water. In concept, each is an attempt to provide the user with the convenience of an indoor crapper without the expense (or ease of maintenance) of a full-blown septic system. Each is the merger (of sorts) of porcelain and privy.

COMPOSTING TOILETS: HOME FOR BACTERIAL BREAKDOWN

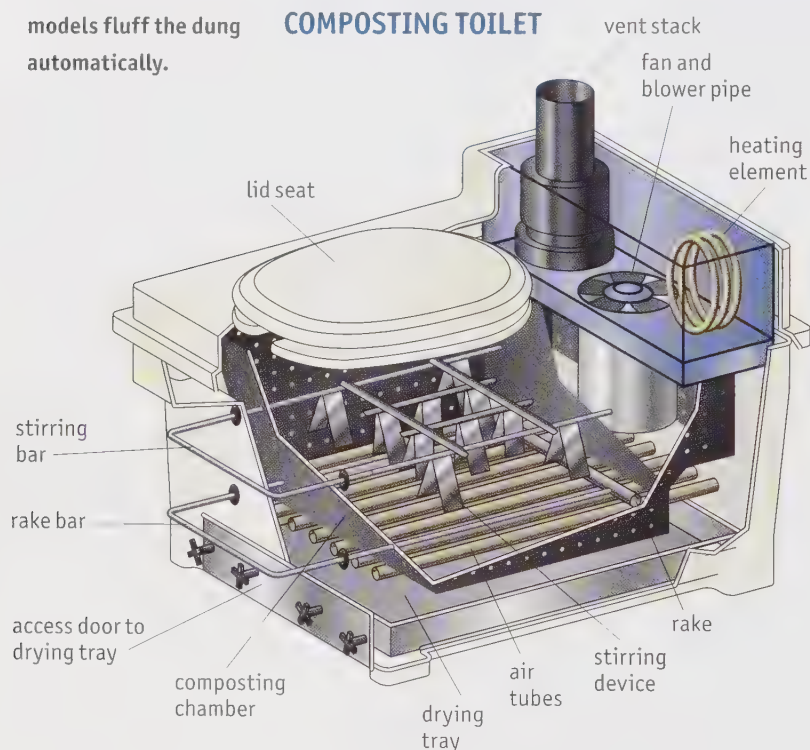
The composting toilet has three basic elements: a place to sit, the composting (or storage) chamber, and some sort of drying chamber or tray. Some models also offer a separate evaporation chamber as part of the unit. Seating and storage can be amalgamated into in a single component (in which case the toilet can be rather bulbous in appearance). Or seating and storage can be detached, with the bit you sit on located in the bathroom and a much larger remote storage

chamber located elsewhere, such as outside or in the basement. (With detached units, the part of the toilet that lives in the bathroom typically resembles a traditional toilet devoid of its rear water tank). On combined units, the drying tray is usually located directly below the composting chamber, and can be removed for emptying. With detached units, an access port is usually provided to scoop out the composted material. Admittedly, whole-house versions serving more than one toilet stretch the “stand-alone” definition but, as emperor and ruler of this book, I have chosen to include them in this chapter because the operating principles remain the same and there is still no septic system involved (unless used for grey-water disposal; see Chapter 10).

Mixing it up:

The sewage in a composting toilet must be aerated for decomposition to occur. This is usually done by stirring or churning the sewage with a hand-operated crank or rake; some electric models fluff the dung automatically.

COMPOSTING TOILET



A composting toilet relies on aerobic bacteria for decomposition, so some method of aerating the sewage must be provided. This airing of the dung is usually accomplished by stirring or turning the sewage inside the composting chamber, which encourages airflow through the goo in much the same manner that stirring hot porridge invites air in to cool your breakfast. Good

news is, stirring of the dung is usually handled via a hand-operated crank mounted on the outside of the unit or, on some electric models, the churning happens automatically. Blowers and fans can also be employed to increase airflow.

THE ODOUR EXIT

In common with normal household toilets, the composting version has a length of pipe aimed outdoors to vent fumes, odours, carbon dioxide, methane gas, and excess moisture. On non-electric models, the heat produced by the composting material is supposed to provide sufficient up-draft to exhaust the fumes up the vent, much as a smouldering fire in a fireplace is supposed to send smoke up a chimney. But any passive vent transporting minimal heat, such as an odour vent without a fan, is subject to downdrafts that can drag what normally goes up back down. Fortunately, extending the length of the vent stack can often improve the draft enough to encourage fumes to travel upward. But this is not always enough to overcome atmospheric inversions.

Exhaust fans can help, and they serve a dual function: to force the fumes up the vent and to circulate air around the sewage. Battery- or solar-powered fans work on non-electric models, while most electric composting toilets incorporate fans as standard equipment. Another option that works for both electric and non-electric sites is to install a wind turbine at the top of the vent stack (think of it as a smaller version of an attic turbine vent).

COLD-WEATHER USE

The bacteria responsible for decomposition work best in a warm climate, about 60° F (15° C) being the preferred minimum. In fact, if the temperature dips below 40° F (5° C), the bacteria go on strike and all decomposition stops. And should the contents of the composter freeze, it may not thaw out and warm quickly enough to function properly when warm weather returns. So if regular cold-weather use is on the agenda, the composting chamber must be well insulated and

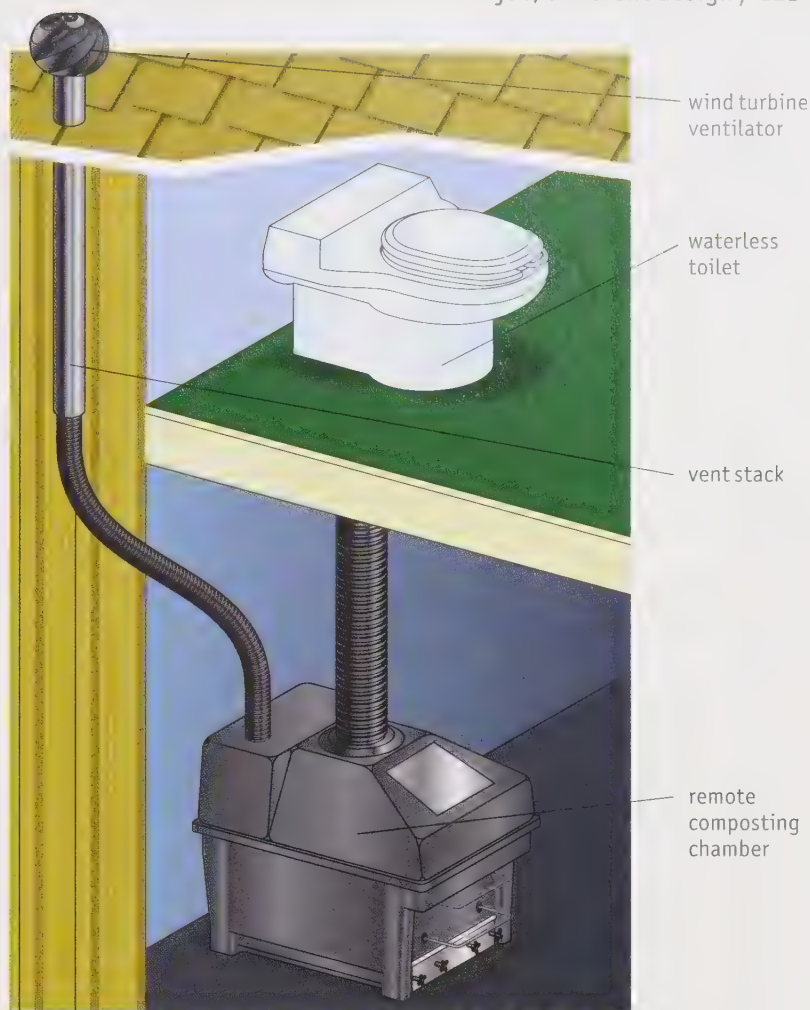
kept warm. Insulating and heating the room in which it's located is perhaps the easiest and most economical way to accomplish this. With remote compost chambers, it may be possible to simply enclose the chamber in a small, well-insulated box equipped with a small heater, as you would to winterize a pump house. (See Chapter 11.) To hasten decomposition and evaporation of excess moisture, many composting toilets have small built-in heaters, the heat being circulated by the fan. Sometimes, this can dry the mix too much, slowing or stopping the composting process. A thermostatically controlled heater will allow you to vary the amount of heat (and electricity) used, so install a thermostat if the heater didn't come with one.

COMPOSTERS THAT FLUSH

Some jurisdictions will permit a low-flush variant of the composting toilet with remote chamber. The flushing action is usually initiated by pressing down on a foot-activated lever that lets the water flow into the bowl while also opening a small spring-loaded gate or a ball valve to let the mix of water and miscellanea drain out to a remote chamber. (For more on ball valves, see Chapter 4.)

While manufacturers tend to label these toilets as “one-pint flush” units, the amount of water scooting through the bowl really depends on how long you keep your foot on the lever, or how often you have to give it another flush to get the sticky stuff to disappear. If restraint is not your forte, a composter's ability to convert your sewage to humus could quickly be overwhelmed, leaving you with a bin full of gloopy poop – and that means contacting the honey-wagon operator for a chamber pump-out.

When shut, the spring-loaded valve theoretically keeps a small quantity of water in the bowl after each flush, this puddle of water creating an airtight seal, which in turn keeps odours from sneaking back up into the bathroom. In practice, the valve and the gasket between either and the bowl are both subject to wear. Once they're worn, the seal is kaput, allowing the water to drain out



REMOTE COMPOSTING TOILET

Split-level sewage:

By separating the throne itself from the business end of the operation, remote composting systems offer the benefit of a much-larger storage chamber situated in an easy-to-empty area that's away from living spaces.

between flushes and the odours to seep in. Bits of toilet paper hung up in the valve can have the same effect. On these toilets, ball valves generally last longer and seal much better than gates.

URINE-DIVERTING COMPOSTING TOILETS

In theory, not mixing urine and feces is a good idea as it greatly reduces the amount of stuff the composting chamber has to deal with. Viewed from its exterior, the urine-diverting toilet looks much like every other composting toilet. But if you open the lid and peer in, you may notice a

small funnel-like chamber at the upper forefront of the bowl. That's your target, your private pot to pee in, whether seated or standing. And apparently it works, though I personally can't attest to its success, having never made it past the viewing stage. So if not headed for the composting chamber where is all the pee supposed to go? Usually into a holding tank or septic system for later disposal, or a much slimmed-down absorption area. Though high in nitrogen, which is good for plants, urine is also a highly corrosive substance, which can kill vegetation. And it smells. So it's not a good idea, nor legal in most jurisdictions, to simply disperse it over the ground, or even into a small leaching pit. However, where permitted, it can be mixed with grey water (typically high in phosphorous), the two working well together to irrigate and fertilize nonedible plants.

THE MATTER OF MAINTENANCE

Regardless of which variation of composter you opt for, you will inevitably have to develop a significantly more personal relationship with it than any conventional toilet you've previously owned. Right off, there's the start-up routine (read the manual and, no exceptions, follow the manufacturer's recommendations). Also, it's the operator's responsibility to regularly monitor the state of the dung heap. Too dry, or too wet, and the composting process stops. To aid this process, you may have to periodically add peat moss, rich topsoil, or some proprietary concoction a manufacturer may sell to assist with composting, accompanied by regular aeration of the dung heap. Adding vegetable matter, once considered a good idea, has proven to attract flies and is now usually discouraged.

At some point, you will have to empty the composter or its drying tray. If all is working well, this is not a big deal, the resultant humus appearing to be a rich, dark soil. However, if the composter is not working as planned, the composting chamber may have to be emptied and cleaned – which is a hell of a job. Because you are dealing with raw sewage at this point, not some environmentally benign humus, technically this

clean-out should only be done by a licensed contractor experienced in handling sewage. Check local regulations. How often these tasks must be performed is governed by such factors as toilet make and model, toilet use, your faithfulness in monitoring and feeding the system as required, the climate, the effectiveness of the non-sewage additives in promoting bacterial growth, and perhaps the phase of the moon. But it does bring up this important tip: Locate the unit so as to make this task as easy as possible.

Do not dump anything into the toilet the manufacturer does not specifically recommend, especially chemicals and toxic cleaning solvents. Bleaches and similar agents to curb smells or clean the bowl will kill the bacteria, leaving you with a chamber full of sludge and a bill for the necessary cleanout. If the manufacturer markets an approved bowl cleaner, using it will likely reduce the odds of succumbing to the dreaded compost failure.

Perhaps the most popular use of composting toilets in North America is for cottages. Typically, this is driven more by economics (a stand-alone toilet being substantially less expensive than a full-fledged septic system) than by environmental concerns. But these smaller units don't have an easy life, being susceptible to overloading following long periods of disuse and, frankly folks, owners who would much rather be boating than looking after the family sewage. So it should come as no surprise when the system fails and things get stinky and gucky. Composting toilets need your attention, if not your love.

COMPOST CONUNDRUM

Composted material must be removed from time to time to make room for new arrivals. While this nutrient-rich material would no doubt help your vegetables grow, composting does not rid sewage of disease. Encysted pathogens, for example, are able to survive for years, waiting patiently for the appropriate host in which to revive themselves. And the material has not always been fully composted. In either case, the disease-carrying microorganisms are quickly taken up in plants, es-

pecially in root veggies such as carrots and potatoes. So under no circumstances should anything that has spent time in a composting toilet be added to a vegetable garden; in fact, it's illegal to do so in many jurisdictions. Fully composted, the stuff is great for trees, shrubs, and flowers – but again, check with local authorities to verify such use is permitted.

A composting toilet's ability to handle our feces and urine is rated by suggested number of users. Exceed the maximum and the unit could stop functioning or overflow. In addition to the humus, there is often some excess liquid, the leachate, to deal with. Some manufacturers install drain pipes on their units to let it out, the narrow pipes susceptible to plugging. And how an owner disposes of the leachate depends on local laws, most jurisdictions insisting that it be disposed of in an approved septic system or public sewage system.

In some areas, it is permissible to let the leachate drain into an approved cesspool similar in design to the grey-water leaching pit in Chapter 10, but this is a poor second choice as the walls of the pit tend to plug very quickly, preventing effective dispersal of the liquid. If a cesspool is your only reasonable option, build it to the higher standards of a seepage pit (see Chapter 7), which is better equipped to handle sewage. Overflow should never be dumped onto the ground or collected in a pail, as one composting-toilet manufacturer suggests. What the heck do you do with the pail when it's full? This is, after all, a pail full of liquid sewage. (Okay, who wants to carry this insidious slop around? Volunteers? Anyone?) Only a licensed hauler of sewage should handle raw sewage.

Continuing this theme of disgusting things to do in your spare time, there is the issue of "skid marks", those unsightly tracings dung can make when exiting the bowl. True, this can be a problem with any toilet, but because there's little or no water used to help wash things away, it's more acute (but not cute) with composters. And you don't want to be using tons of water or cleaners to get rid of those mean streaks, because that will hamper what's going on below the bowl. In-

stead, dry wipe or moist wipe or use restrained blasts with a water gun.

Prices for composting toilets average about \$1,000–\$2,000.

INCINERATING TOILETS: THE WASTE GOES UP IN SMOKE

Using either electricity, natural gas, or liquid propane as its energy source, an incinerating toilet heats the sewage to about 1,200° F (650° C) or so, boiling away the liquid and then converting the residue to a powdery ash. (According to rebellious members of my family, this result bears a striking resemblance to my grilled dinners.)

All incinerating toilets must have an approved chimney to vent the smoke and combustion gases to a safe point above the house or cottage roof line.

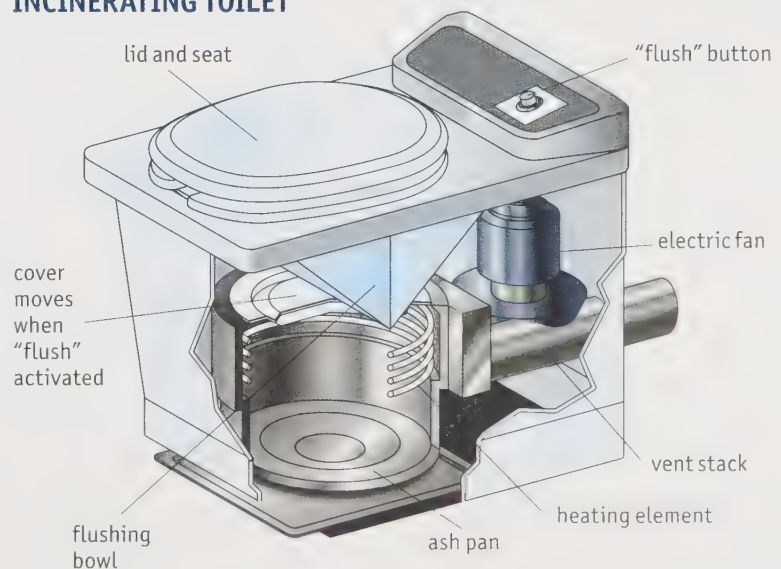
ELECTRIC TOILETS

With electric models, incineration takes place after each dump. Close the lid, flick a switch, and a radiant heater starts cooking the excreta, TP included. The ash collects in a pan below, which

Hot prospect:

Incinerating toilets can be fired by electricity, propane, or natural gas. After the combustion process, all that's left is sterile ash which, depending on local regulations, can be treated like woodstove ash when it comes to disposal.

INCINERATING TOILET



should be emptied at least once a week, the frequency dictated by use. A fan blows the smoke and fumes up the chimney and helps cool the unit following incineration. This in turn reduces the temperature of the gases flowing up the chimney, so depending on local building codes, electric models may only require a PVC plastic pipe for venting.

Should the need arise (“Clear the decks, it’s chili payback time!”), incineration can usually be interrupted by a switch or similar device, but the fan must remain on until the unit has cooled. At least one electric model has a catalyst (similar in concept to the catalytic converter on an automobile’s exhaust) to help reduce smoke and odours. The catalyst depletes with each use, and therefore the quantity of catalyst remaining must be monitored and topped up as required.

GAS-FIRED TOILETS

Natural gas or liquid-propane units rely strictly on high combustion temperatures to vent the smoke and fumes up the chimney, so local building codes may demand a 6" metal chimney, with insulated sections where it passes through a wall or ceiling (a good idea even if not required by law). Since no fan is required, a propane-fired loo may make sense for sites lacking electricity. However, as with non-electric composting toilets, its chimney is a passive vent, so odours could be a problem between firings.

Rather than store the ash as electric models do, natural gas or liquid propane incinerators usually have some limited excreta storage capacity (about 4 US gal. or 16 L), allowing you to bank a few deposits before initiating the fecal flambé. The cook tosses in a packet of anti-foaming agent (to keep the poo-brew from boiling over), secures the lid in the locked position, ignites the burner, and about 4½ hours later the lock releases (the toilet’s out of commission during the burn).

Remove the ash (there will be about a cup of it) after each incineration to avoid corroding the container, and the toilet is ready for action again. A small, hand-held vacuum works great for this task. If the burner is turned on after everyone

has gone to bed, down time shouldn’t be a problem. Besides, it teaches good self-discipline.

Those who schlep supplies into a remote site should know that a 50-lb. bottle of propane is good for about 300 deposits.

DISPOSING OF THE ASH

Because the by-product of any incinerating toilet in good working order is sterile ash, assuming local regulations don’t state otherwise, ash can go in the ash can, or anywhere you might get rid of the ashes from a woodstove. However, the concentration of nutrients per ounce of ash is high, so the ash must always be disposed of as far away from open water and wells as possible.

Incinerating toilets are waterless and not dependent on ambient temperature, and are therefore open for business regardless of ambient temperatures. Which brings up the point that, with some units, you may even be able to heat a super-insulated home simply by incinerating your dung. (Picture the family standing in a circle with their backs to the toilet, singing campfire songs as Aunt Mable fuels the stove. And should the weather take a turn for the worse, you can always hand out laxatives.) This benefit, of course, isn’t much of a plus in the summer.

Toasty toilets cost about \$1,700–\$2,000 for the electric varieties, and about \$3,000 for those cooking with gas.

TOILET CHEMISTRY

Chemical toilets come in many shapes and sizes, united only in ideology: each is a chemical bathtub for excreta. The chemicals of choice vary, but usually can be classified as caustics, dyes, perfumes, preservatives, or some combination thereof.

Sodium hydroxide (caustic soda) or lye, both caustics, work by burning and corroding organic tissue, liquefying the solids while killing bacteria in the process. A dye changes the colour of sewage (chemical toilet aficionados apparently preferring blue or green to natural brown) while

perfumes merely compete with the dung for odour superiority. Dyes and perfumes do nothing to reduce the pathogens in sewage, and are usually added in conjunction with a caustic or preservative. Preservatives such as formaldehyde kill bacteria, but they also prevent decomposition, leaving us with the dilemma of what to do with a bowl full of dung.

The problem with disposing of the effluent from chemical toilets – or from composting or incinerating toilets for that matter – has not been addressed by many jurisdictions. The contents of a chemical toilet, unlike the other stand-alone toilets, will destroy the bacteria a septic tank, absorption area, or cesspool depends upon to function. So even folks with a septic system on the property who might have a chemical toilet in an unplumbed guest cabin, for instance, cannot use the septic for disposing of the contents of the chemical toilet. The only realistic solution is to call the honey-wagon.

As the quantity of sewage from a chemical toilet does not diminish through decomposition or leaching, frequent pump-outs will definitely be required – which can get expensive when the toilet has minimal storage capacity. (Whether it's a small bucket or a full-sized tank, you pay about the same rate to have it pumped out.) Fortunately, some models of chemical toilets have remote storage chambers in which the concoction can accumulate (similar to the remote chambers of some composting toilets), or are designed to work with holding tanks. Both of these variations will increase the time between pump-outs.

For many folks, the main objection to most chemical toilets is the smell. Perfumes or no, these toilets are often a real drag to share sleeping quarters with. Often, this odoriferous reputation is due in part to their portability, which makes installing an effective venting system difficult. Low-flush variants of the chemical toilet with remote storage chambers claim to have less of an odour problem while offering a modicum of self-cleaning action; however, on any of the models I have observed in action, these benefits seemed to be more brochure bragging than fact. And of course, adding more liquid to the brew

will increase the frequency with which pump-outs are required.

Splashback can also be a problem on some models lacking remote storage tanks. Considering that the exposed portions of a seated visitor rank as some of humanity's most prized possessions, who would knowingly put such highly regarded organic tissue at risk of corrosion? (Maybe a little preservative wouldn't hurt on occasion, but is this the best way to apply it? And how do you explain those weird stains from the dye to an inquisitive mate?) Fortunately, toilets with built-in splash pans are not as likely to besprinkle those on the throne.

As chemical toilet shapes and sizes vary, so do prices. They start at about \$100 for the porta-bucket variety, while models with remote sewage chambers are competitive in price with composting toilets.

OTHER STAND-ALONE CONSIDERATIONS

OPERATING COSTS

Beyond the purchase price of these toilets is the cost of operating the unit. For instance, there's the aforementioned costs of frequent pump-outs for chemical toilets, as well as the costs of adding – and the hassles of handling – dangerous chemicals. And, with the exception of chemical toilets and non-electric composting toilets, these alternatives to the outhouse consume significant amounts of energy. Incinerators, especially, can be quite costly to operate, about 40¢–50¢ a dump in my neck of the world. Composting units used much in the winter will need to be heated constantly, which costs again. A GFCI (ground fault circuit interrupter) may be required for any bathroom appliance (like a toilet) using electricity, a point overlooked in most instruction manuals. (The basic rule is that any bathroom outlet easily reached should have a GFCI.)

Also, some rural electrical systems may not be up to the added draw of a heated composter, let alone an incinerating model. If you have any

doubts about the system or the necessity of a GFCI, have the building checked out by an electrician or the electrical power company serving your area.

VENTING

Operating a standard bathroom vent (sometimes required by building codes) or even opening the bathroom window may result in backdrafts. For air to exhaust out of a building, there must be air coming into the building to replace it, called make-up air. Air tends to exhaust through the hole offering the least resistance, make-up air being drawn in through the next-biggest hole. For instance, it may be easiest for bathroom air to leave through an open window, the make-up air then being drawn in down through the vent stack, casually wafting over the sewage before dispersing throughout the building. So keep the window shut, auxiliary fans off, and the bathroom door shut, leaving enough room under the door for fresh air to be drawn in.

Stand-alone toilets equipped with fans are better at venting but can be irritatingly noisy, especially in a typical seasonal cottage where bathrooms sit smack dab against bedrooms, with few sound-deadening materials between them. A speed control (or rheostat) can reduce the noise, but slowing the fan also reduces its efficiency, which may interfere with the composting process and increase odours. That said, being able to control the speed of the fan also gives you one more way to regulate the evaporation rate of the composting toilets.

Just like outhouses, many of these units can be difficult or even dangerous for small children to use unattended, which can sure put a lot of extra mileage on an adult's sneakers.

CHECK WITH THE LAW

Contrary to some manufacturers' statements, these devices are not universally approved for use. Nongovernment approvals such as CSA, UL, or NSF are certainly good things to have, but do not in themselves guarantee that the unit is

approved for use in every jurisdiction. In some cases, such an approval only means that a portion of the product – the electrics, for instance – may have passed inspection for use, not the entire product.

Never wishing to make life simple, it naturally follows that governmental approval and conditions for use typically vary for each jurisdiction. For example, some jurisdictions issue approval of stand-alone toilets for abatement purposes only (meaning as a stop-gap measure to reduce the load on a failed septic system or outhouse) but not for new construction. In other areas, they're approved for use in buildings that lack pressurized plumbing, or in seasonal dwellings only, or in cottages situated on lots large enough to accommodate an approved septic system should the need arise (such as when a cottage evolves into a full-time residence).

Many jurisdictions demand that you apply for and receive a waiver from existing regulations before installing any of these toilets. And most jurisdictions permitting the use of stand-alone toilets demand that they be accompanied by some form of approved grey-water treatment system, ranging from a full-sized septic system to a leaching pit.

Some government agencies even express open reservations about these toilets. For instance, according to Nova Scotia's Division of Public Health Engineering, "Problems such as odours, maintenance, and flies have been reported with all these disposal systems," while Massachusetts' Division of Water Pollution Control states that it has been the division's experience "that not all of the equipment which falls into this category performs as advertised," causing the division to "proceed very cautiously" with approvals.

But perhaps the biggest area of confusion, for governments and users, is in the disposal of the treated and untreated sewage from these toilets. There's no consensus among legislators as to what to do with the stuff. Massachusetts says bury it all under two feet of clean earth; in Wyoming you must have a licensed contractor tote it away to an approved treatment facility; Ontario

allows disposal of it into an approved cesspool; other jurisdictions will even let you put it in a bucket or dump it anywhere you want, except maybe down a well or into the lake. It all depends on your locale. And to add to the confusion, in at least one instance policies within the same government agency contradict one other. (No surprise there, really.)

READING BETWEEN THE LINES

Of course there's scarcely a hint of this problem in the manufacturers' brochures. Stand-alone toilets seem to suffer from the same brochure hyperbole as water-treatment devices, the public having to now be wary at both ends of the water system. I can handle the endless brochure pictures of folks beaming with ecstasy at their toilets – after all, having a place to do your business is a fine and wonderful thing – but not the ridiculous claims of “no pollution.” Since when did excreta suddenly stop having an effect on the environment? None of these devices can rid dung of nitrates, phosphates, or toxic metals, and most cannot even guarantee the killing of pathogens. Most will, however, reduce pollution. Much to-do is sometimes made over the fact that these composters have been classified as a “Class One” system by a government environmental agency. Although this sounds like quite an accomplishment, all it means in reality is that the government in question has seen fit to rank the toilet on par with the outhouse. Stuff and fluff, what's a poor body to do?

BEFORE YOU BUY

Before buying any of these toilets, get approval – in writing – from all the government bodies that preside over your locale for installation and use of the exact model you intend to purchase, and for any other related systems required in conjunction with the unit (like grey-water systems, cesspools, etc). This may include getting permission from the local health unit, building department, municipality, state or province, and maybe Jimi Hendrix and Elvis, too.

Because of the expense and bulk of these units, few retail outlets are willing to stock and display them, so chances are you will only be able to inspect them at a consumer show, such as a boat or cottage show. Most of the manufacturers offer “show specials” at these affairs, which can translate to savings of a few hundred dollars. But unless you have received all the necessary government approvals prior to visiting the show, do not yield to temptation. Instead, talk to the people displaying the product, and ask for and

SUGGESTED MINIMUM SETBACKS AND CLEARANCES FOR A CESSPOOL

(check with local authorities for approval)

Bottom of pit to high groundwater table	4'	(1.2 m)
Open water or spring	100'	(30 m)
Wetland	50'	(15 m)
Drilled well with a watertight casing 20' (6 m) deep	100'	(30 m)
Dug or driven well	200'	(60 m)
Pump intake (suction) line	100'	(30 m)
Pump intake (suction) line	10'	(3 m)

read copies of the warranty, installation manual, and troubleshooting guide before buying and taking delivery of the unit. This reduces the potential for surprise.

No matter how you look at it, our dung is our mess. It stinks, it's full of pathogens, and it attracts flies. A well-designed stand-alone toilet allows us the opportunity to personally do something about the mess before it creeps into the watershed and returns to us via our drinking water. No city sewage system, septic system, or outhouse offers us that advantage. For this reason alone, stand-alone toilets are worth considering.

Be warned: The effectiveness of any stand-alone toilet is dependent as much on our willingness to do what is required to keep it working as it does on good design. Those who are not interested in such a commitment should steer clear.

INSECTS AND TOILETS

There's no question that excreta attracts flies. This in itself wouldn't be a problem if it weren't for the tendency of the same flies to visit our food stocks without washing between flights. So for health reasons, not to mention avoiding the unpleasant experience of having them buzz our undercarriages while we are seated and engrossed in deep thought, the pesky insects need to be kept away from the toilet.

Incinerating toilets are not as disposed to fly colonies because the dung and everything else aboard get scorched regularly. Composting toilets (especially the non-electric variety) and chemical toilets are more likely targets for stop-overs. The best way to keep out flies is to prevent access. The tops of vent stacks (on non-incinerating toilets only) can be covered in a fine mesh screen, though this may restrict air flow, necessitating a larger diameter, or taller, stack. (Your nose will tell you if it's not venting properly.) Obviously, for reasons too disgusting to even mention, screening is not the ticket for the toilet opening, so keep the lid down when the toilet is not in use.

Flies can be discouraged from entering the bathroom by making sure the house or cottage is well screened and the bathroom door remains closed (which also aids stack ventilation). Check all joints in the pipes leading from a toilet to a remote chamber, and ensure that the lid of the chamber seals tightly when closed. Flies are also less likely to be attracted to composting toilets that are functioning correctly, so follow the manufacturer's recommendations regarding startup and regular maintenance. And don't add kitchen scraps to the composter: Flies love that stuff.

Hang flyswatters in easy-to-reach places and encourage their use. If there's room in the composter, also hang a sheet or roll of sticky flypaper. And try adding a sprinkle of compost additive after each visit, which helps to cover the mess and discourage fly contact. Chemical insecticides should only be used as a last resort, and never on the dung heap itself.

Advantages of an outhouse

Where to put your privy

How deep to dig

Solving the odour problem

Variations on the theme

Design considerations

Cold-weather comfort

9. THE HUMBLE OUTHOUSE

Still considered by many to be the best seat in the house

THE OUTHOUSE IS THE original restroom: a place to sit, think, and sometimes stink. A few mornings ago I frittered away a moment in silent repose, outhouse door jammed open as it usually is, contemplating absolutely nothing as seven ruffed grouse balanced awkwardly on the top twigs of the closest birch tree, doing the same as me. Beyond lay the meadow and wetland draped in morning mist, enveloped in the mysterious sounds of the woods. From this hill-top vantage point a hop, skip, and jump from our indoor loo, I could almost see the septic system leaching bed. It's tough to beat the view.

ADVANTAGES OF THE PRIVY

Yet the pleasures of the outhouse are not restricted to grand views. For instance, a neighbour brings his reading material to ours, claiming squatter's rights for at least as long as it takes him to get through a chapter or magazine article. Other users declare it to be the best spot to enjoy

that second cup of morning coffee. And, lest we forget, it also serves as an admiral receptacle for bodily wastes. Which brings up the point that there are sound, logical reasons for owning an outhouse.

Contrary perhaps to public perception, an outhouse – backhouse, biffy, privy, loo, or whatever one chooses to call it – is an environmentally friendly way to dispose of human waste. Because backhouse sewage is not nearly as fluid as the household mix we send to a septic system, the leaching of nutrients into surrounding soils and from there into our waterways is greatly reduced. We know that many septic systems aren't up to snuff. Also, research by enlightened government agencies (yes, there are some) has revealed that the flow of sewage from a dwelling (equipped with all the usual amenities) to the septic tank can be reduced by as much as 40% if an outhouse is also used.

It therefore stands to reason that, spared the task of handling human waste, an existing sep-

tic system of questionable efficacy may be able to cope quite nicely. And without the solid-waste factor to deal with, the life of a brand new septic system is extended, being less likely to deteriorate and become plugged. Plant a biffy outside an unplumbed guest cabin, and again you reduce load on (and line ups at) the main system. And – here comes the clincher – outhouses are inexpensive to build and operate.

Still not sold? Indoor sewage systems – including composting toilets and chemical toilets – must constantly be kept above freezing to remain operational. The cost and impracticalities of heating a cottage (and often the incoming water lines as well; see Chapter 11) when no one is there usually leads to the annual draining of the pipes, and hence, no pot to pee in during winter visits. And both home and cottage systems are at the mercy of nature during power outages. But an outhouse is open for business all year, anytime, in any kind of weather.

CHECK FOR RESTRICTIONS

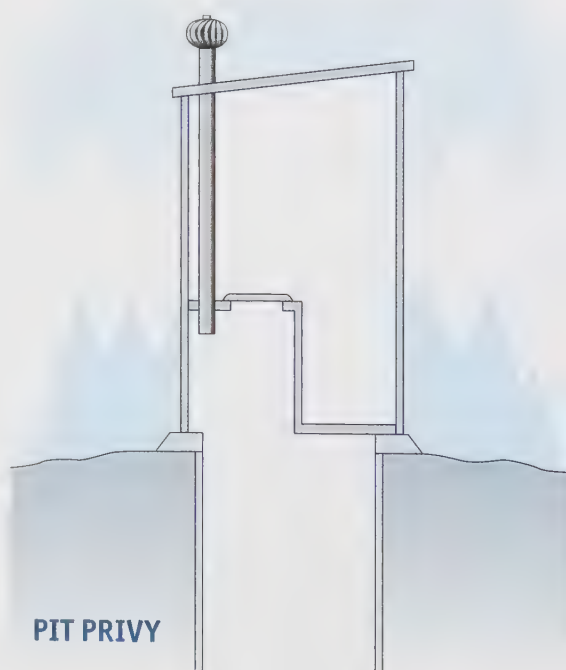
You would think that any device that reduces the environmental impact of our various excretions would be greeted with considerable enthusiasm by those government agencies in charge of dung. Regrettably, this is not generally the case. Many jurisdictions have banned outhouses, while others may limit use to seasonal cottages in remote areas, specifying type and size. You may also be required to have an approved septic system or at least a grey-water system to handle liquid household wastes. And local authorities often place additional restrictions on use. So check for all building and backhouse bylaws that pertain to your area before beginning construction.

Governmental concerns over outhouses are not all hot air. Health problems have been associated with outhouses that were located too close to drinking-water supplies, or built so as to al-

low rodents and insects into the works to pick up pathogens and thereby spread disease. And outhouses are not the ticket in highly populated areas. Yet could not the same criticisms be levelled against the septic system? In both cases, the key to minimizing impact is good planning and careful siting.

THREE VARIATIONS ON AN OUTHOUSE THEME

There are three basic types of outhouses – the pit privy, the vault privy, and the pail privy – all looking essentially the same from the floor up. The pit privy is the original enclosed frontier john, basically the traditional outhouse structure built over a pit or hole in the ground. Although this allows some sewage to leach out into the surrounding soil, most of it remains trapped in the pit. The bottom of the pit should be at least 4' (1.2 m) above the high groundwater table, the hole surrounded on all sides and the bottom by no less than 2' (60 cm) of earth. The sides also need to be reinforced to prevent cave-ins (very inconvenient if you happen to be engaged in outhouse activities at the time). Recycled concrete blocks, laid in place dry



Privy possibilities:

A pit privy (near right) consists of the traditional outhouse structure built over an open hole in the ground. With a vault privy (far right), the sewage is held in a tank (or vault) which must be pumped out when it gets full.

with no mortar between joints, work well, as does building a crib out of 4" x 4" (or similar) fir. By the time the fir rots, the hole will likely be full, necessitating a move to a new site. The earth around the base of the house must be built up 6" (15 cm) or more above the surrounding ground level, the ground in turn being graded away from the pit to keep rain and melting snow from draining into the dungeon of dung.

The vault privy is like a pit privy except that all excreta is held in a vault, or tank, below the outhouse or, if the outhouse is raised, to the back or side of the structure. It's much like an outdoor version of the holding tank in that no leaching of sewage occurs; the sewage is merely stored temporarily and must be pumped out when the guck rises to about 12"–18" (30–45 cm) below the outhouse floor (keeping in mind that an empty vault may float during spring melts or rainy seasons). Even where a vault privy is not the government-mandated style of backhouse, it should still be considered when soil conditions do not permit adequate clearance from the high groundwater table. In some areas, the mandatory setbacks for privies are reduced when a vault privy is installed. The vault itself is usually built of concrete

(or similar watertight material) with an external rear hatch about 24" (0.6 m) square to facilitate clean-out.

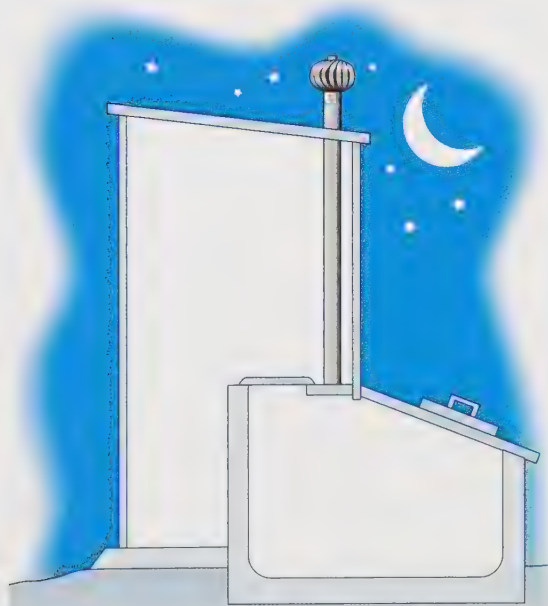
An interesting variation of the vault privy converts the vault into a composter (see Chapter 8 for composting toilets). Usually, the composting bin sits outside a raised outhouse building, taking advantage of the sun's rays to keep the contents warm and cosy, and its outdoor location also makes it much easier to access the composter for servicing or emptying.

The pail privy is like a vault privy with drastically reduced capacity. A pail sits below the seat (or the two are combined), directly on the floor. When the pail is full (which could be quite often), it must be emptied – and who wants to lug around a pail full of dung? And where do you dump the stuff? If you have an approved spot on site, why not do the job there in the first place? All very revolting (not to mention dumb), and running counterpoint to the romance of outhouse use.

THE HOLE MATTER

What should go down the outdoor loo hole other than human body waste? Soiled pages of catalogues, toilet paper (TP), and that's about it for pit privies. In other words, no vegetable matter, diapers, sanitary nappies, or grey water. This will no doubt be a bit of a bummer for those who favour the traditional corncob for completing the toilet ritual. Generally, the same rules apply for vault privies, although some jurisdictions do allow the grey water from a kitchen sink and a hand basin to drain into the vault.

How big a hole does a backhouse need to accommodate our mountain of digested decadence? Some jurisdictions solve the question of size by stipulating a minimum capacity rather than dimensions. When such minimums are not set, for pit privies, a hole 3' (1 m) square by 3' (1 m) deep should see most cottagers through a lifetime of holiday contributions. For full-time ruralists, double the depth. And in either case, if you have any doubts, make the hole deeper, keeping in mind that a high-water table or the



VAULT PRIVY

presence of bedrock may restrict pit depth. At a very minimum, the hole should be no less than 2' (60 cm) deep. This yields a mere 1' (30 cm) for movements before the building needs moving, the remaining 1' (30 cm) being required for the capping off the abandoned hole.

If the terrain won't permit at least that depth, find a new spot or switch to a vault privy or composting variation. Vault size is usually set by legislation, but in jurisdictions where capacities are not stipulated, figure on a minimum of 25 cu. ft. (2 m³) per person per year.

Mostly anaerobic bacteria, with a few aerobic pals hanging around near the top of the heap, are working diligently on your behalf to reduce the volume of family wastes, but even when aided by evaporation and seepage, the mountain beneath still grows. We inherited our cottage privy from previous owners who left no record as to how deep the hole was and, to be honest, we didn't check current depths with the real estate agent before we bought. ("Ah, excuse me, can I borrow a tape measure?") Two years later it was darn near standing room only in the backhouse, a situation compounded by the fact that the structure was slowly sinking into its own pit. So we dug a new one – a wonderful hole just shy of 6' (2 m) deep by a 3' (1 m) square shored up with old cement blocks and discarded railway ties –

and moved the old building to its new home. By my calculations, we'll be too old to make the trek out there by the time it needs to be moved again.

Cover abandoned holes with at least 1' (30 cm) – and preferably more – of fill to keep pests out and dung in. (Some jurisdictions demand that the pit be pumped out first.) We stuck a small tree on top of everything at our old site, and it's doing fine, thank you.

HIND SITE: WHERE'S THE BEST SPOT FOR THE PRIVY?

Choosing a site for the outhouse is sometimes more difficult than digging the hole. First, it must be on the same property as the dwelling it serves, so that narrows it down some. Then, most jurisdictions have minimum setback requirements similar to those listed in the chart below, so that eliminates a few more choices. It should also be downgrade from any well and not placed in an area prone to flooding. Although regulations in some areas permit the building of an outhouse smack dab against a house or cottage wall, consider that although this certainly would cut down on the walk, winds do carry odours. So give yourself at least 20' (6 m) between living quarters and spending a penny, but keep the path under 200' (60 m) unless you're having the chauffeur drive you there during bouts of inclement weather. ("Shut the motor off, James. I may be a while.")

Once having delineated all possible locations, choose the one that offers the best view. A valley, the sky, a peek at the lake, a small clump of favourite trees – virtually any scene that breathes relaxation will do. A panorama of plugged highways won't suffice, whereas a single sumach might be just dandy. And whenever possible, the outhouse door should face due east, letting solar heat warm the seat first thing in the morning when the day's coldest temperatures are out to greet bared flesh.

View being a reciprocal thing, privacy is another good reason not to face a highway, whether that thoroughfare be on land or on water. The path leading up to the backhouse should be shel-

SUGGESTED MINIMUM SETBACKS AND CLEARANCES

(check with local authorities for approval)

Bottom of pit to high groundwater table	4'	(1.2 m)
Open water or spring	100'	(30 m)
Wetland	50'	(15 m)
Dug or driven well	100'	(30 m)
Drilled well with a watertight casing 20' (6 m) deep	50'	(15 m)
Pump intake (suction) line	100'	(30 m)
Dwelling	20'	(6 m)
Property line	10'	(3m)

tered from onlookers too, with trees, shrubs, or latticework carpeted in climbing plants lining the approach. Although it fails to provide year-round coverage, my personal choice for outhouse-approach vegetation is the Outhouse Plant. At least that's what it's called in my neck of the woods. Much of the remaining world know it as the cutleaf coneflower, a.k.a. Golden Glow, or by its Latin binomial, *Rudbeckia laciniata*. But by any name, it's a grand addition to general outhouse ambiance, a perennial wildflower that sports a plentiful crop of bright yellow flowers, each measuring about 1"-2" (2-5 cm) in diameter. The plant grows fast – in sun, shade, good soil, poor soil, sand, clay, wet or dry. And if it's in good soil (such as what you might expect to find near the fertilized surrounds of an outhouse), they'll grow about 6' (2 m) high the first year, and up to 9' (3 m) high in the second or third year. Because of its ability to grow so large so quickly, and smell so sweet, the Golden Glow became a natural choice for outhouse vegetation; hence the alternate name. One caution: These wonders can also get really bushy, taking over the outhouse, making it more like sitting in the garden than on the can, the loveliness of the setting making it harder to find an unoccupied seat.

Another hot tip regarding the path is to “have her go past the wood-pile”. This sage bit of advice comes from Lem Putt, the fictional outhouse builder extraordinaire, whose collected wisdom on the subject appears in *The Specialist*, a booklet first published in 1929 (actually written by American humorist Charles Sale). This practical approach to routing accomplishes two things: the gathering of wood for the stove or fireplace, and the concealment of the real reasons for one's venture down the garden path.

DESIGNING THE OUTHOUSE

In the past, biffy architecture often reflected the design themes of adjacent structures. Brick walls (as in “built like a brick...”), peaked roofs, barn roofs, gingerbread trim – even the influence of famous designers such as Ludwig Mies van der Rohe, Frank Lloyd Wright, and Salvador Dali

can be traced to outhouse design. If you like company or prefer a selection of sizes (one size doesn't fit all), try a multiple-holer. Two's company; six is a party. And it doesn't have to be a box. I visited one octagonal beauty that offered four inward-facing pews (or was that pee-yoos?).

But for the ultimate in one-upmanship, insist on a two-storey job. These gems evolved into being in areas that received sufficient snow to block the lower entrance. Although the upper deck did have its own chute leading to the pit one and a half storeys below, turn-of-the-century plumbing wasn't as watertight as today's, giving new meaning to the phrase “Look out below!” Guaranteed, a double-decker will keep the neighbours talking for years.

A shed-roofed outhouse is the simplest and least-expensive style to build. It also works well from an ergonomic standpoint, being higher at the front where you enter, and lower at the back where you sit.

TAKE A PASS ON THE PLYWOOD

As for building materials, the bottom sill or anywhere the outhouse comes in contact with the ground is one of the few places I wholeheartedly endorse the use of pressure-treated wood, specifically the type designated PWF (preserved wood foundation). However, some jurisdictions – like Indiana, for instance – insist on nothing less than a concrete floor. (In fairness, it should be noted that the same outhouse regulations of the Hoosier state also call for “comfortable seats,” without question a praiseworthy goal.) Above ground, use a wood (and a colour scheme) that will complement the exterior finish of the dwelling it serves. If you're a traditionalist who doesn't fancy the modern hinged toilet seat, use a hardwood such as oak for the combination bench and seat top; elsewhere, any construction-grade wood will do – except for sheet goods. Stay away from plywood and other wood-and-glue composites for anything but the roof since porcupines and other gnawing rodents love to munch on the stuff. Deprived of their preferred diet though, these pesky varmints may feed on any wood, in-

cluding the sacred bench. We spread a coating of cayenne pepper (in paste form) over the lower quarter of the outhouse, which discouraged the porcos enough that they transferred their culinary interests to our cabin. Other deterrents include a few rows of asphalt shingles around the bottom (shingles also being the best waterproof cover for the roof) or galvanized sheet metal for those into glitter.

Galvanized sheet metal is also the material of choice to line the interior sides of the bench to protect the wood above ground from rot. The metal should extend just below the bench, down into the hole.

Lem Putt suggests that every outhouse of any standing have a 4" x 4" corner post running from the roof down 5' (1.5 m) into the soil, making it very difficult to push the building over. Better safe than sideways, I guess.

A measurement that often falls short in outhouses is the space between the bench and the door. Regardless of one's gender, you need room to stand up and tuck in without bumping into bits of building. A foyer approximately 2' (60 cm) from door to bench and 4' (1.2 m) from side to side is minimum elbow room for a one-holer.

DOOR DOS AND DON'TS

Many jurisdictions require that the door be self-closing. This runs counter to that important requirement for a view. Not that I generally subscribe to civil disobedience, but one way around the problem is to hitch the door open with a string tied to a nearby tree. The door stays open when you're aboard, then slams shut when unhitched. A solution perhaps more palatable with the privy police is to install a self-closing screen door in addition to the normal one. This offers the advantage of a full view, and it holds the bugs at bay. Obviously, one of the doors would have to open inward (not allowed in some areas), which tends to intrude on the working area; so if you opt for this route, leave extra room inside.

My personal favourite outhouse door is the so-called Dutch door, which is divided horizontally in two, allowing the top to be opened in-

dependently from the bottom. This is the door you see on stables in paint-by-number kits, usually with a horse sticking its head out of the top half. Self-closing hinges are installed on the lower section, the upper section being hinged in a normal fashion to the structure. The two sections are connected by a latch bolt so that when bolted together they operate as one, and the door is self-closing. But unlatch the top, and that portion swings open. You get privacy and you get the view. The height of the lower door is about 3' (1 m), but check it before cutting by sitting down on the bench, assessing the view, and taking measurements.

The upper edge of the lower door is also a great place to put a shelf just big enough to hold a coffee cup. An angled footrest attached to the bottom of the door, within reach of weary feet, will be appreciated by those with shorter legs.

In colder climates, the door latch should allow for fluctuating alignment due to frost heave. As the building moves, the hole the latch is supposed to mate with moves, and the door won't shut. The solution is to elongate the hole, making it easier for the rambling latch to find its way home. Or you could opt for the simple and time-proven hook-and-eye for an interior latch.

CONTROLLING ODOURS

The way to handle fumes is to provide an easy exit for odours via ventilation. For the primary vent stack a 3"-4" ABS plastic pipe running from just under the bench to about 2' (0.6 m) above the roof, installed either inside or outside the house, will let pit or vault gases bypass the outhouse interior on their way to the atmosphere. A secondary vent stack, such as a 1½" ABS pipe similarly installed, will let fresh air in to replace the vacating fumes. Both pipes need to be screened at the top to keep bugs out. Adding a wind turbine ventilator to the top of the primary stack will help draw the foul air out.

The outhouse proper should be vented too, preferably at the sides just below the roof line (the roof overhang helping to keep the rain and snow out), and the vent openings should be screened

A BRIEF ON BETTER BACKHOUSE BUILDING

The following is a short guide to construction techniques for a traditional shed-roofed, one-holer pit privy with wood floor, 4' wide x 4' long x 7' tall (at the front). All dimensions – and hole count – can be expanded to suit user requirements and the stylistic inclinations of the builder, all advice subject to local building codes. (For plans, see p. 140.)

Use 2" x 6"s on edge for floor framing and a 4' x 4' for the Lem Putt corner post (see p. 138); standard construction-grade 2" x 4"s serve well for the remainder of the framing.

A distance of 7' between the floor frame and the roof frame at the front and 6' at the rear (making for a gentle 3" rise in 12" run) provides adequate headroom for most visitors, the lowest part of the roof being directly above the seating area. However, professional basketball players may want to increase these dimensions.

Seat height (from the floor to the top of the seat bench) should be between 12" and 16" (depending on family ergonomic preferences), the frame of the bench consisting of 2" x 4"s on 16" centres front, top, and back. (Keep the space directly above the hole wide open and clear of obstructions.) Install the galvanized metal liner before nailing the top framing members in place; if you try to install it after the seat frame is built you'll have to tip the outhouse on its side. Set the hole about 2½"–3" back from the front seat riser.

The 2" x 4" wall studs can be placed on 24" centres, tying in with the seat front. Headers are required at the top and the bottom of the walls (these headers known as top and bottom plates) and above and below a window. A door only needs a header above it. Exterior wall sheathing can be applied horizontally directly

over the framing, but if vertical siding is to be used, the framing will need to be strapped (24" on centre) to provide sufficient nailing spots.

The roof should be approximately 6' square, leaving a 10" overhang at the sides, 9" at the rear, and 9½" at the front. The roof frame is made from 2" x 4" rafters running front to back on edge, 16" on centre again, with single 2" x 6"s at the front and back of the roof to act as headers. Install the vent stacks. Roof sheathing can be plywood or 1" x whatever boards.

If you want a skylight, use a sheet of Plexiglass or Lexan. A 16" square is a good size, allowing it to sit over a 14 ½" opening cut between the centre rafters with no additional framing needed. Install the Plexiglass (or similar plastic) as you would a shingle – that is, the bottom overlapping the shingles below, the upper edge being overlapped by the shingles above, and screw it in place (predrilling the holes). Use silicone caulking to seal it to the shingles and to seal out the weather. Use rubber vent gaskets where the vent stacks penetrate the roof, incorporating them into the shingle pattern as well.

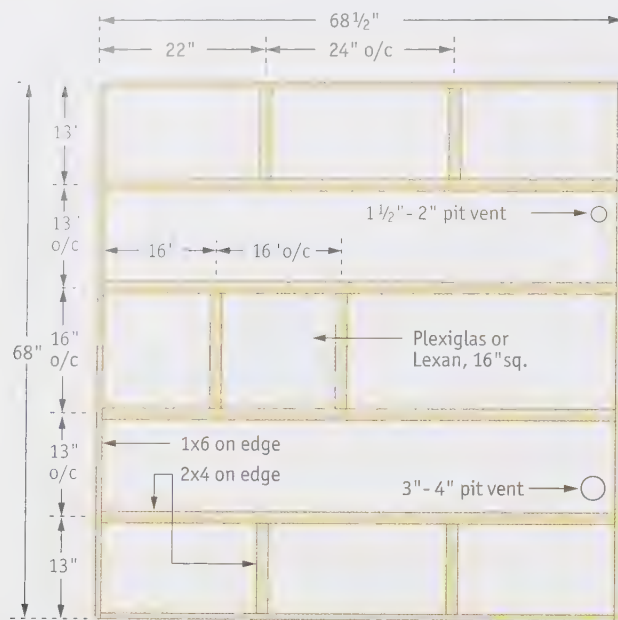
Install a wind turbine ventilator on the primary stack after the roof is done.

The easiest door to make uses 1" x 4" or 1" x 6" shiplap or tongue-and-groove boards butted together, with a Z-shaped support glued and screwed to the back, using 1" x 6" wood. A minimum ⅛"–¼" space between the door and its frame, and also between the two halves of the Dutch door, allows the door to function without binding. Overlapping the frame of the lower section of a Dutch door with the cladding of the upper by an inch or more will help keep the weather out.

of course. In some jurisdictions, you may also be required to install louvred vents just above the floor to increase air flow (not a big advantage during cold spells).

What about a window, which provides not only much-needed ventilation, but also light and a view? The problem is where to put it. The back wall is out because you can't see out but I can peek in – and what's the point of peeking if nobody knows you're doing it? If you have a side with plenty of privacy, by all means, stick a window there. My own preference is the flat, Plexiglas or Lexan non-opening skylight for light.

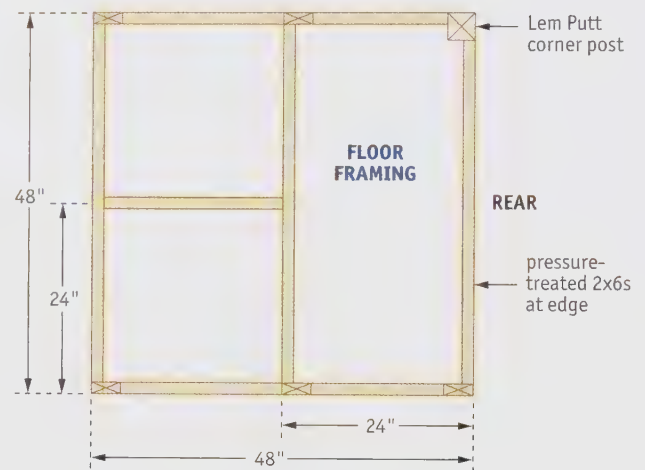
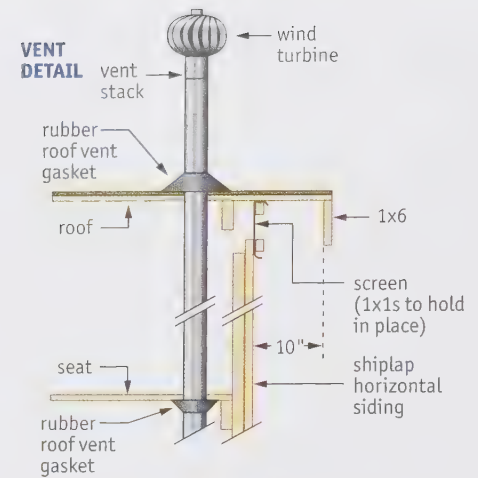
That said, a friend recently upped the outhouse envy quotient when he salvaged a discarded 4' x 4' (1.2 m x 1.2 m) domed skylight that had misted up, that translucent cast-off now part of his outhouse roof. (With both a skylight *and* a Dutch door, you're approaching biffy-nirvana.) The final addition is the classic cutout on the door. Yes, it lets some air in too, but its original purpose was to serve as a system of outhouse classification, the quarter moon signifying ladies, the star (or sunburst pattern) signifying men. As for non-gender-specific loos, let your imagination guide you.



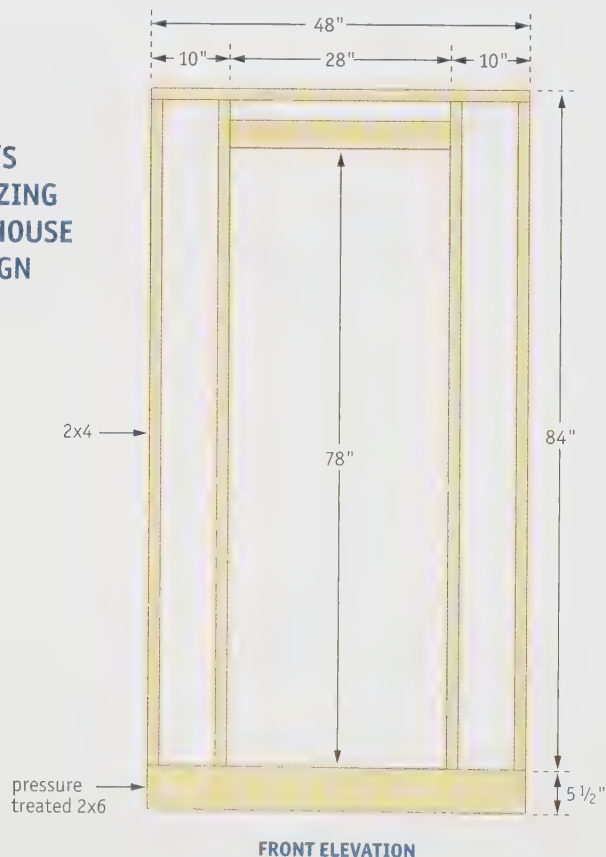
ROOF FRAMING

Style and substance for the original restroom:

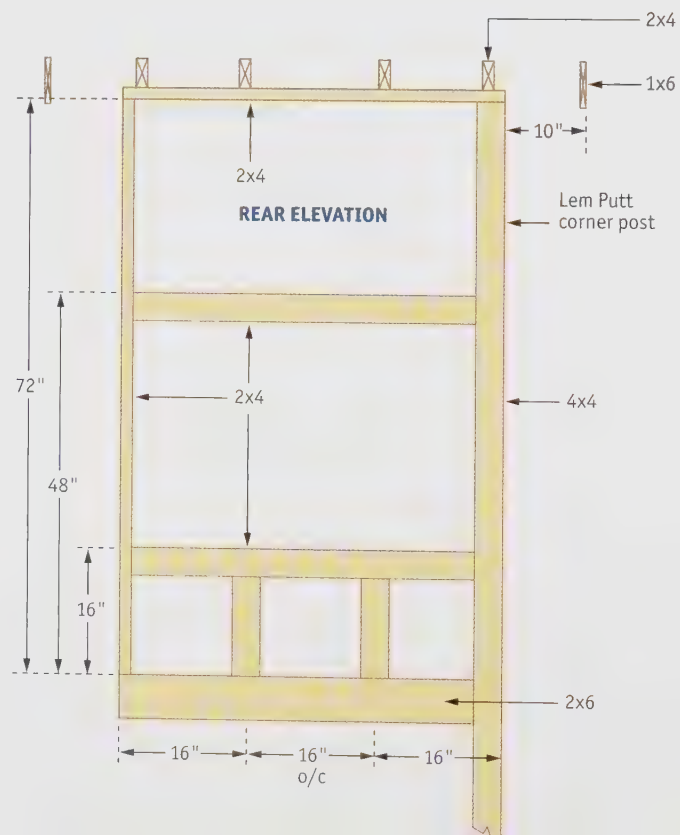
A shed-roofed outhouse is simple and inexpensive to build. This design features a few of my outhouse preferences, including a Dutch door, a skylight, and a turbine vent. You can adjust the dimensions and the hole count to suit your personal requirements.

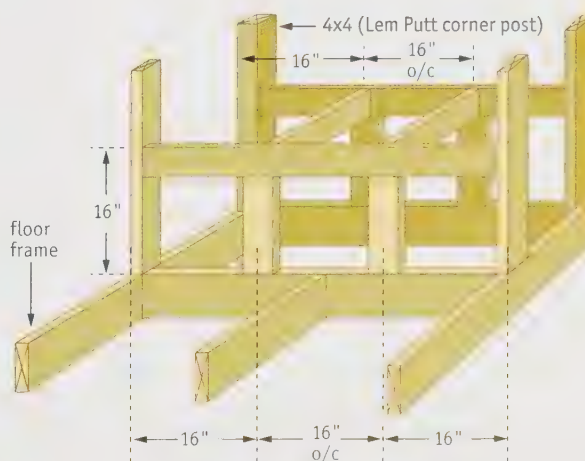
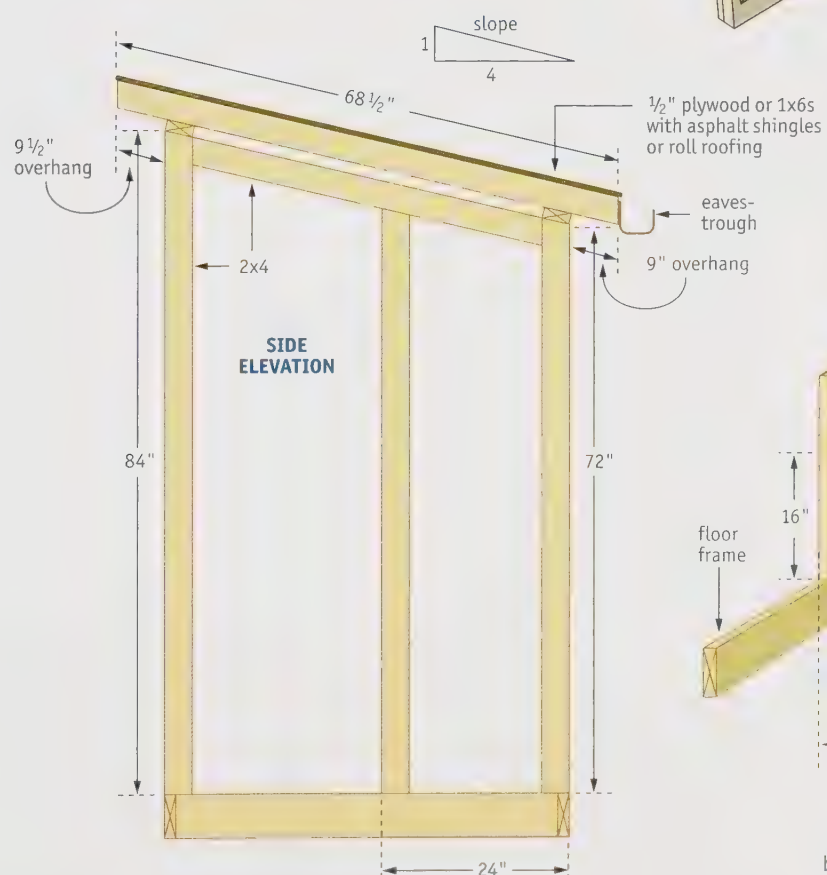
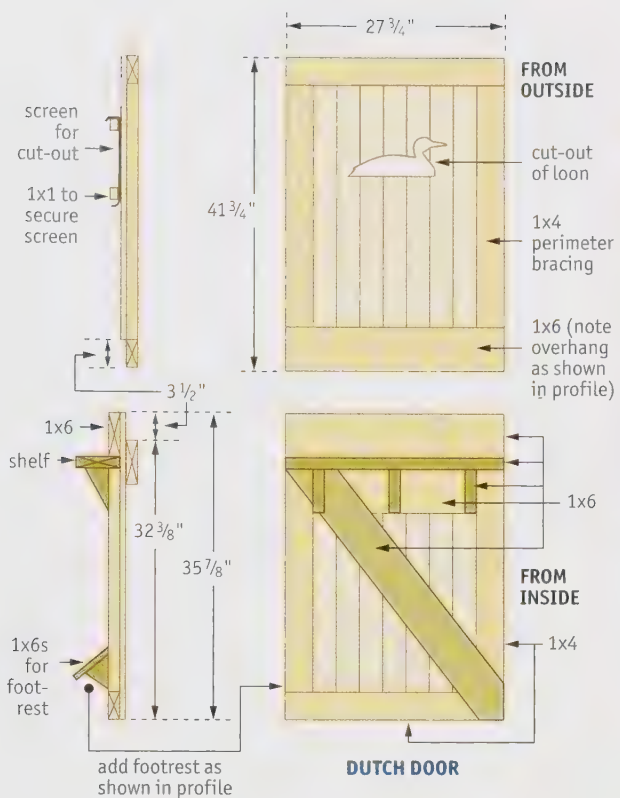


MAX'S AMAZING OUTHOUSE DESIGN



FRONT ELEVATION





install galvanized metal liner in bench before nailing top framing members in place

Small quantities of a type of lime known as calcium hydroxide can occasionally be added to the outhouse mix to control odours. It's used in stables for that purpose, is inexpensive, and is sold through feed stores. But handle it with care: both inhalation of its fumes and contact with skin can cause health problems. A more benign and less expensive alternative is ash from the wood stove. It's not as effective as lime, and may be harder to come by when odours reach their highest potential – the heat of summer.

Through the ages, outhouses acquired a reputation as places of filth and disease because many of them were – and still are – filthy. We

scour our bathrooms, down on hands and knees scrubbing the floor, wiping the very bowl, yet rarely does even the swish of a broom grace the outhouse floor. There is no requirement, government or otherwise, that an outhouse assume the sewage-lagoon ambience of a service-station john. This sanitary neglect is the pity of the privy, because a spiffy biffy makes a body feel welcome.

SEAT DESIGN

Traditionally, the hole in the bench had a lid, much like the one on a Halloween pumpkin. The user removed the lid and then sat down right on the bench itself, the perimeter of the hole being bevelled for greater comfort. Nothing touched the seat but skin. Now, an indoor-style toilet seat (preferably a tight-sealing version to keep bugs out and fumes in when closed) usually tops the hole, which most consider to be a great advance in comfort. The problem of this modern addition is that many handyman specials do not allow for the variety of angles expelled urine can embark on from a seated position. Now to be honest, I know of no research to back me up on this point; I am only assuming this to be the case based on years of after-the-fact observation in poorly designed outhouses.

It all has to do with the modern toilet seat to old-style bench interface. If the bench hole is not of the right size, shape, or position in relation to the toilet seat and lid above it, urine originating from any gender can miss its mark. This is especially true for younger visitors, but certainly not restricted to them. Proper delivery to the pit will only result if the hole is pear-shaped, not circular. If the hole is going to be topped by a toilet seat, make it as large as possible, leaving enough material around the perimeter to support the seat plus the weight of any occupant. (You wouldn't want any fallouts with your friends.) This should work out to about 11" long x 9" wide (at the fat part of the pear) but, if in doubt, let the indoor porcelain bowl be your guide.

Should you decide to do without the seat, choosing to go with the traditional hole in bench

FROZEN ASSETS

If you've got your sights set on four-season service, beware the rising mound of frozen excrement that continues to build skyward all winter like a fecal variation of the Tower of Babel. (Should the tower rise to intrude on sacred ground, outhouse visitors have been known to call out in a language foreign to most folks of proper upbringing.) The remedy is to wait for spring thaw or use a long stick to topple the tower. (This latter act explains the historical significance behind that well-known expression about getting the unsavoury end of a stick.)

Without question, the most important cold-weather survival gear an outhouse user can own is the expanded polystyrene foam ring, probably best known as that white foam doughnut kids use for floating about in the water. Serious outhouse users know it as a seat. It never ceases to amaze me – and other outhouse visitors – how well this plebeian device works for a job it never applied for. At -20° F (about -30° C) the ring remains warm to the touch of bare buttocks, even when left out all night. Colder than that, and it tends to frost up if left out, so we bring ours in as the Fahrenheit and Celsius scales start to converge, carrying it back out on each trek until the thermometer rises again. A double caution: The extra height of the ring compounds any problems related to poor hole design, and the inner surface of the ring can acquire a coat of wake-me-up-quick frost if left sitting over the hole during severe cold snaps, so hang it up between duties. If you can't find a prefab foam ring, you can carve your own out of a sheet of Styrofoam SM. It's a slightly messy task as tiny bits of polystyrene get strewn about but it does offer one important advantage – greater insulation value per inch, which translates into a thinner seat and a warmer bottom.

By the way, the outhouse is a swell place to hang a thermometer. Not only does it bring you up to date on a regular basis, it supplies plenty of fodder for those competitive hard-times tales exchanged between friends.

with lid, reduce the hole dimensions by about an inch in all directions.

While we're on the topic of open holes over sewage-filled pits, youngsters should never be allowed to use any outhouse without some adult supervision (or an emergency escape ladder).

OPEN AND SHUT CASE

Having already advised readers on how to circumvent the law regarding self-closing doors, I will now boldly expand my criminal activities to include self-closing seat lids. In some jurisdictions a self-closing seat lid is mandatory. This piece of bureaucratic buffoonery was obviously fabricated by some ass whose cheeks have never touched an outhouse bench. For a lid to be self-closing, it cannot of its own free will remain up and out of the way. According to this logic, a visit to any law-abiding outhouse would therefore require an occupant to manually hold the lid up until seated. Then, with back to the wall, the occupant is attacked by the lid as it clamps down on its victim like some giant butt-biting clam, pinching exposed nether regions as it snaps shut. And for menfolk, the contortions required to keep the lid and seat up just to have a leak are enough to get you arrested.

When statutes start accumulating more dung than your average outhouse, it's time to empty them and install a self-closing feature for the law books.

ACCESSORIZE

If rodents are a problem in your neighbourhood, TP will need to be stored in a lidded container. The mice around our place don't seem to take much notice of our TP, perhaps because we use the cheap, recycled stuff. Regardless of brand loyalties, keep an extra roll handy in a weather-proof container. When the extra roll gets used, the container comes in and is set by the door with care, with a new roll ready inside for the next trek to the privy. Failure to notify the world of TP consumption in accordance with these rules is punishable by death.

An old dish drainer, cut in half, makes a dandy magazine rack. The open concept discourages rodents from taking up residence in the reading material. And every outhouse needs one or two coat hooks, particularly if you want to hang up your hat and enjoy the view for a spell.

What is this stuff,
anyway?

Putting in a
leaching pit

Testing soil
permeability

Alternatives to
the pit

Separate tank
systems

Grease traps

Recommended
setbacks

10. GREY WATER

Neither fresh nor foul, it's in a league of its own

WHILE THE PRECEDING three chapters document our ongoing search for the ultimate dung-disposal device, regrettably the same effort has not been applied to the problem of what to do with the grungy water that's left after washing up. Yet anyone with a privy or waterless-type toilet must also have a means of dealing with grey water.

Grey water (also known as sullage) is the water, soap and miscellanea we create whenever we rinse or wash something – all of our liquid waste, excluding the fecal and urinary stuff handled by the toilet. While the main contaminant in grey water is phosphorus, principally from modified soaps and detergents, the list of ingredients is only limited by what is available to scrub off; it often includes bacteria (like fecal coliforms), protozoa, viruses, animal greases, and petroleum-based whatevers (which can include everything from man-made edible goodies to paints and solvents). In fact, all of this and more can blossom from a single wash-up for dinner. So how do you get rid of it?

In many jurisdictions, you don't have a choice: Even if you own and operate the latest in nonflush toilet technology, you still must have an approved septic system to handle your grey water. Some jurisdictions will allow stand-alone toilet users to reduce the size of the required septic system, a few limiting that modest concession to the absorption bed only. (In such cases, the tank must remain full size.) Some states specify performance criteria rather than quantitative regulations for grey-water systems. For instance, New York asks that such systems be “designed upon a flow of 75 gal. per day per bedroom and meet all the criteria previously discussed for treatment of household wastewater,” leaving the manufacturer or installer responsible to prove that the device being proposed meets those “previously discussed” conditions.

As a means of dealing with a few buckets of dirty wash water, any of these restrictions is severe overkill. Yet for dwellings equipped with pressurized water systems that include hot-wa-

ter tanks, tubs, showers, and maybe even a dishwasher, anything less would be woefully inadequate. So minimalists often get stiffed. Unless, of course, you live in an area that permits the use of a minimal-flow system dedicated to grey-water use.

THE LEACHING PIT

Although giving grey water a toss into the bush was once considered appropriate technology, it became apparent that such freestyle waste disposal methods weren't in the best interests of humanity or the environment. So we devised the leaching pit. Simplicity is the pit's biggest advantage – essentially we're dealing with a sink (normally in the kitchen) draining through a pipe via gravity into a hole in the ground.

Inside this hole, four walls are constructed of stone, concrete block, or brick, dry laid without mortar to allow for outward seepage of the surlage. In some jurisdictions, a perforated container, like a barrel riddled with small holes, can be substituted for the masonry walls. In others, leaching pits are only approved for cottages that are not year-round residences and for those equipped

with non-flush loos. Increasingly, leaching pits are regulated by input volume. For instance, in Ontario, the maximum daily flow into a pit must not exceed of 264 US gal. (1,000 L), each fixture in a pressurized water system deemed to contribute 53 US gal. (200 L) per day, with unpressurized systems pegged at 33 US gal. (125 L) per day.

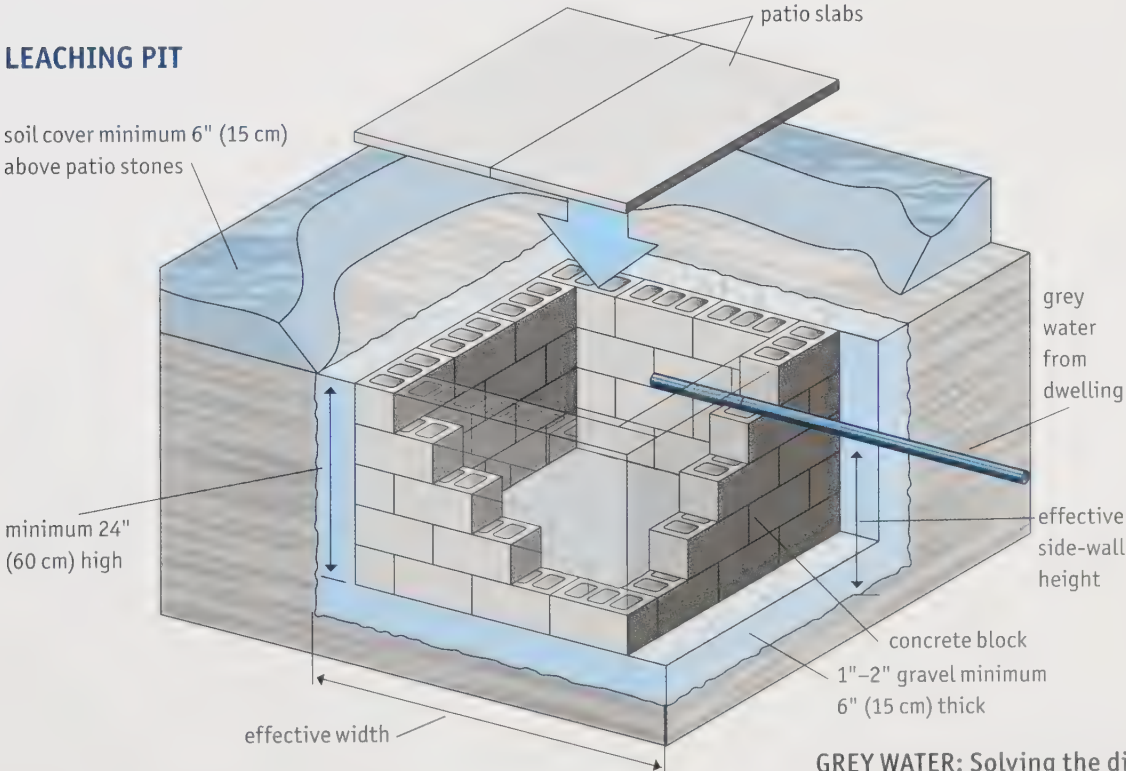
The walls of the pit should be a minimum of 24" (60 cm) high, and surrounded by at least 24" (60 cm) of soil having a percolation time of at least 50 minutes (see sidebars for explanation and calculation). The floor is built of 1"-2" gravel a minimum of 6" (15 cm) thick, and must sit at

SUGGESTED MINIMUM SETBACKS AND CLEARANCES FOR LEACHING PITS

(check with local authorities for approval)

Bottom of pit to high groundwater table	3'	(1 m)
Open water or spring	100'	(30 m)
Wetland	50'	(15 m)
Dug or driven well	100'	(30 m)
Drilled well with a watertight casing 20' (6 m) deep	50'	(15 m)

LEACHING PIT

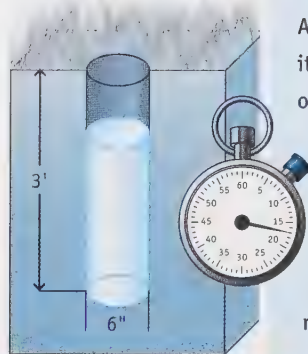


Pit parameters:
A basic leaching pit consists of four walls built from concrete blocks or brick, dry laid without mortar, then surrounded by a 6" (15-cm) envelope of gravel. This simple box is capped with concrete patio slabs and covered with soil.

least 6" (15 cm) above the water table. The same grade of gravel also surrounds the outsides of the four walls. The easiest way to top off the pit is to lay square concrete patio slabs over the opening (your choice of 14 decorator colours), and mound dirt (such as the pile you accumulated digging the hole) up over the top at least 6" (15 cm) high, so that rainwater gets the hint to drain away from the pit. Also for drainage reasons, the pit should never be located in a depression where

HOW TO DO A SOIL PERCOLATION TEST

A percolation test determines the permeability of your soil, which dictates the required size of your pit. Dig a small-diameter hole (6"–8" or 15–20 cm) about 3' (1 m) deep (a post-hole auger works well for this); pour a bucket of water into the hole and time how long it takes, in minutes, for the water level to drop by 1" or 1 cm (depending on your metric or imperial inclinations). In the formula for establishing leaching-pit size, the percolation time is referred to as T.



Assessing your soil:

In order to determine how big your leaching pit needs to be, you have to do a simple percolation test. It's easy – just dig a hole to the required size, pour in a bucket of water, and time how long it takes for the water level to drop.

rain and grey water are apt to mingle, nor should it be placed under any structure where the pit is difficult to service.

CALCULATING PIT SIZE

The total size of the pit, also known as its effective size, is determined by the permeability of the surrounding soil and the estimated volume of grey water it's going to receive. Effective pit size is the area available for leaching, which includes the surrounding gravel. Similarly, the effective sidewall height is the distance between the bottom of the pit, including gravel, and the bottom of the inlet pipe. The permeability of the soil is determined by a percolation test (see above). Having figured all that out, we then throw simplicity into the bush instead of the grey water, and test math skills that have lain dormant for years.

First, estimate how much water is likely to

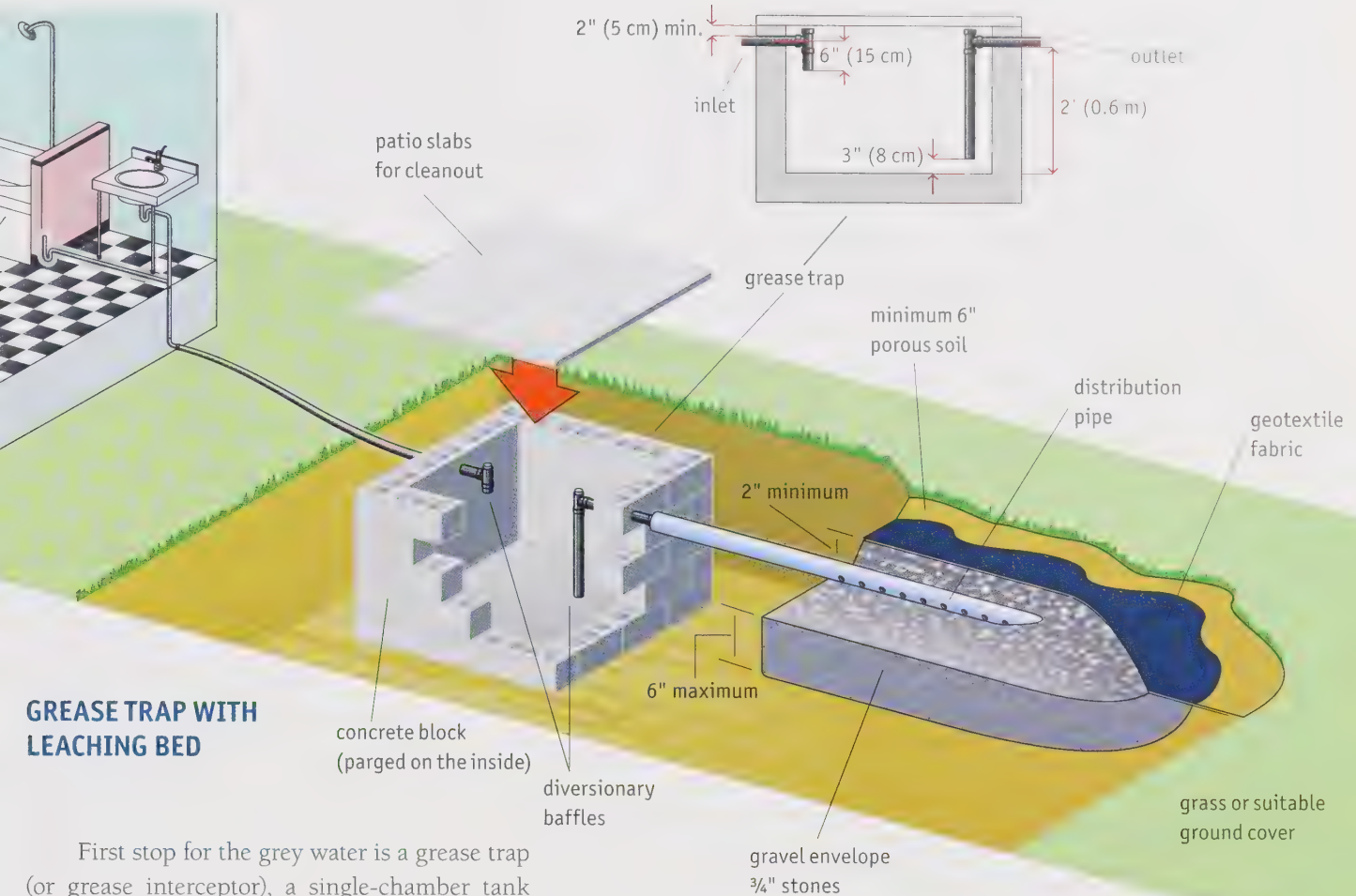
be used in a day; then divide that quantity by the number of people contributing to it to get the per-capita flow per day. If not regulated by volume per fixture, and fed by an unpressurized water system, figuring out water consumption is pretty easy. For instance, how many buckets do you bring up from the lake or well per day? How big is the bucket? At our family cottage, two people used approximately 8 US gal. (30 L) per day, which equates to a per-capita flow per day of only 4 US gal. (15 L). Granted, this is substantially less than average, the normal leaching pit per-capita use being 5–37 US gal. (20–140 L) per day, but it does illustrate both the method of calculation and how little water one can get by on. The final bit of information you need is the number of the bedrooms – best counted by having a nap in each one.

With the above figures calculated and on paper ("I thought you were writing them down!"), we just plug the numbers into the formula given in "Math Is The Pits" (p. 148) and voila, we get the required sidewall area of the pit. From the area, we can calculate the dimensions of the pit walls suitable for our grey-water outpourings.

Although inexpensive and easy to build, a leaching pit has limited capacity. Also, because greases and solids are sent directly to the leaching mechanism (that is, the pit) without first being separated out, the side walls of the pit are easily plugged. Fortunately, there are better options for a grey-water treatment system (and this is especially true in jurisdictions that permit the use of leaching-pit-style cesspools to catch the overflow of composting toilets).

THE SEPARATE TANK SYSTEM

When it comes to grey water, the province of Nova Scotia does it better. Realizing the need for a system that can handle greater quantities of grey water, the province allows what is in concept a miniature septic system, complete with downsized tank and absorption area. It's not meant to handle the effluent from automatic clothes washers or dishwashers, but it will handle grey water from all sinks and even a shower.



GREASE TRAP WITH LEACHING BED

First stop for the grey water is a grease trap (or grease interceptor), a single-chamber tank about 60 US gal. (225 L) in size. Like the larger septic tank, it can be concrete, concrete block, plastic, or fibreglass. (Check with local authorities for specifics in your area.) Grease is held in the trap, and the trap is pumped out when full (just like the septic tank), while the rest of the grey water travels on to a leaching area. Depending on local regulations, this leaching area could be a pit filled with gravel, similar in design to the leaching pit described above, or an absorption area with distribution pipes, similar in design to a septic system, but reduced in size.

The advantage of this two-tiered grey-water system is that by separating the grease from the rest of the grey water, thereby keeping it out of the leaching area, you greatly extend the life of the system – assuming, of course, that the trap is maintained by periodic pump-outs. The system is more expensive than a leaching pit, and more work to install. But if your grey water use is relatively high – greater than 80 US qts. or 75 L per

capita per day – a grease trap and leaching area is much easier on the environment than a limited-flow leaching pit. And with the blessings of the local sewage police (and to the relief of friends), you get to have a shower too.

BUILDING A GREASE TRAP

Should your cottage reside in an area that suffers an absence of commercially available grease traps (try the local plumbing supply outlets), here are some construction tips for building your own. The trap walls and floor can be built from standard 6" or 8" concrete block, or even brick, parged on the inside. This is not a difficult task, but if you are unfamiliar with block-laying techniques, or are fond of your hammock, a mason should be able to assemble a trap at little cost. As with the leaching pit, concrete patio slabs make for a sound, inexpensive cover. In-

Going one better:

A two-stage grey water system is a bit like a miniature septic system. The grey water first goes through a grease trap, then travels on to a leaching area. This setup is easier on the environment and lasts longer than a basic leaching pit.

MATH IS THE PITS: HOW TO DETERMINE PIT SIZE

If you are working in metric, use this formula for determining side-wall area in square metres:

Per-capita flow in litres x number of people x number of bedrooms, divided by 400 over T.

For example, the estimated flow at Joe Canuck's cottage is 20 L per person per day, and there are three people fighting over two bedrooms. T is equal to 10 minutes per cm (T must always be equal to or greater than 4). Therefore, $20 \times 3 \times 2 = 120$, and 400 divided by 10 = 40, so 120 divided by 40 = 3 m² in sidewall area. If the pit has an effective sidewall height of 0.6 m–0.45 m from the bottom of the back wall to the bottom of the inlet pipe, plus 0.15 m of gravel – the perimeter would be 5 m (the side-wall area divided by the height, or 3 divided by 0.6).

This translates into a rectangle 1 m wide by about 1.5 m long if we want to keep it the right width for easy installation of the patio-slab top. If you want the perimeter of the pit to be smaller, the side walls will have to be higher, which means getting out the shovel to dig a deeper hole.

If using the US system of measurement, the following formula applies for determining the area of the sidewalls in square feet: per capita flow in US quarts x number of people x number of bedrooms, divided by 100 over T (T being equal to or greater than 10 for this formula). For example, the estimated flow at Frank's cottage (Frank being Joe's American cousin) is 20 qts. per person per day, and again there are three people fighting over two bedrooms. T is equal to 25 minutes per inch. Therefore, $20 \times 3 \times 2 = 120$, and 100 over 25 = 4, so 120 divided by 4 = 30 sq. ft. in sidewall area. A pit with an effective sidewall height of 2' would have a perimeter of 15', so a 3' by 6' rectangle would more than fill the bill. (Bimeasural folks will note that Joe and Frank's requirements are about the same, therefore so are the leaching pits.)

Of course, should the local septic police be using a different formula, ignore the above and use theirs. But wasn't it fun doing all that math anyway?

side the trap, the intake must be above the outflow, while the lower edge of the outflow pipe (at the point where it exits the trap) should be at least 2' (0.6 m) above the bottom of the tank. To control flow and prevent grease from escaping, both intake and outflow pipes point downward like an elephant's trunk. The lower edge of the intake downspout should be 6" (15 cm) below the intake pipe's centre line, while the outflow's snout should end about 3" (8 cm) above the bottom of the trap. Allow at least 2" (5 cm) above the

intake pipe for grease build-up. Again, as with the leaching pit, mound earth at least 6" (15 cm) over the top of the trap to keep out rain.

PUTTING IN THE ABSORPTION AREA

The absorption area for this type of grey-water system is constructed in the same manner as absorption areas for septic systems. (See Chapter 7.) For the average unpressurized water system, approximately 50' (15 m) of distribution pipe or channel in an absorption trench will usually do the trick. Use the clearances and setbacks for septic systems as the standard for grease traps and the grey-water absorption area, though local authorities may allow some reductions. Another absorption option is the artificial wetland, perhaps the most efficient way to take care of grey water. (See Chapter 7 again.) But the solution most likely to win the annual area ornamental garden award is to use grey water to irrigate flowers and shrubs, running the distribution pipes beneath the surface directly below the vegetation. This system, and the artificial wetland for that matter, work better in colder climes when tucked away in a greenhouse.

Because a waterless stand-alone toilet in conjunction with an effective grey water system uses dramatically less water than any conventionally plumbed system, it dumps much less effluent into the environment. This combination of dry toilet and minimal water use is the most environment-friendly way to deal with personal wastes. It's a shame that such an approach to reducing pollution should be so restricted or forbidden by governments, rather than encouraged. When forced to install fully plumbed septic systems, people inevitably use more water, and nature picks up the tab. The less we dump on nature's shoulders, the easier it is for her (or him) to cope.

11. WATER IN WINTER

Designing a system for cold-weather convenience

The hole-in-ice approach: Ice and augers and axes

Importing water

Winterizing pressurized systems

How to insulate the lines

Self-draining systems

Heated water lines

Thawing-out frozen pipes

THE PROBLEM OF WATER in cold weather is that, once frozen, it's not very good at flowing through pipes to taps or toilets. But there are ways to sneak around nature's narrow-minded "closed for the season" approach to marketing.

The construction usually dictates the type and design of water system best suited to the situation. For example, if it's an uninsulated cottage you don't plan to visit during the cold-weather season, then you don't need to worry about getting water to it, and out of it, when the world around it freezes. Visit for a week or more and you'll not only need a reliable source of drinking water, you might need a bath too.

BACK TO BASICS: THE HOLE IN THE ICE

You can melt snow or ice in a pot on the stove, but it's a slow process and doesn't produce a heap of water for the effort involved; the equivalent

of about 1" (2.5 cm) of water for every 10"–12" (25–30 cm) of snow. It is, however, a convenient source for an afternoon stay, perhaps yielding enough water for hot drinks all around. For more water, you're better off poking a hole in the ice, then carting the water up to the cottage in suitable containers (preferably equipped with tight lids to prevent the water from sloshing onto you during transit). Wait until the ice is sufficiently thick to support your weight and then some (a minimum of 6" or 15 cm) before venturing out with a suitable ice-chopping implement.

TOOLS FOR THE TASK: AXE VS AUGER

Most neophytes reach for the axe. Long ago, about the time I ruined two very fine elbows as a result of a day's worth of chop-'til-you-drop forest-management practices, I realized that an axe's role in life is best restricted to horror stories told around late-night fires. The axe as an in-

**Hole notes:**

A manual auger makes getting through the ice easier, and can bore through 3' (1 m) of ice in about 10 minutes. They might be noisy, but gas-powered augers are much faster and a lot less work.

strument of serious work is ideal for people who feel obligated to work, not for those who enjoy work. For instance, up in our neck of the frozen north, the ice is usually about a 3' (1 m) thick by midwinter. It takes about a day to hack away a big enough gash in ice that thick to get a small bucket through, and another day to rest up and maybe pay a visit to the chiropractor, by which time the hole has frozen over again. With an ice chisel – a 6' (2 m) or so long metal rod about 1"–2" (3–5 cm) in diameter and bevelled at the chopping end – you can carve out a suitable hole in about two hours, with a bit of work. Much better, right? Yet a hand-operated auger will do the job in a mere 10 minutes. But for folks really eager to get the job done, a gas auger cuts through the same thickness of ice in about a minute. That said, those keen on preserving the tranquillity of their surroundings should opt for the hand-operated auger.

Any hole in the ice should be fenced off or, if less than 1' (30 cm) in diameter, marked with a 6' (2 m) vertical stick to warn others of thin ice. A marker also helps to locate the hole later, saving you from having to bore through the thickest part of the ice every time a cup or two of water is required for hot drinks.

If the water required treating during the summer, chances are it will also need treating during the winter, though microorganisms, like people, aren't as likely to be mucking about when the temperature plummets towards the dangerous-to-brass-monkey zone. (See Chapter 6 for water purification solutions.)

Another option is to import water. It doesn't have to be carbonated or come from France – it can be locally treated bottled water, or come from your own city tap. Importing water to the cottage is particularly convenient for day visits, or even the occasional weekend sleep-over, guaranteeing a reliable source of drinking water.

You'll also be in need of a reliable place to dispose of excess bodily fluids. For this, nothing beats an outhouse, ready to serve in any weather. (To build a perfect privy of your own, see Chapter 9. Or take a look at Chapters 7 and 8 for indoor options.)

FOR MORE WATER: WINTERIZING A PRESSURIZED SYSTEM

As in the warmer months, a pump remains the best method of getting larger quantities of water to the house or cottage. The traditional displacement hand pump can be used all winter if it is situated directly over a well or if the intake line runs at a steep enough slope (see below) to allow the water to self-drain back to its source. The pump must be drained after each use (see Chapter 12). The pump's flapper valves can freeze open or shut between uses, a problem solved by pouring a bucket of hot water over the top of the pump (so you still might have to melt some snow).

We used a hand-operated diaphragm pump one winter, carrying the lightweight pump and buckets down to the water, pumping the water through a 1" hose into the buckets, and then carting the water and pump back up to the cottage. No worry about frozen lines or electrical power outages, and small holes are much easier to make in the ice than large ones. However, our supply of water was limited to whatever we could carry.

For folks with greater water needs (or less enthusiasm for manual labour), a pressurized water system is the answer, just like in any city. Unfortunately, unlike the city, the responsibility for keeping the system from freezing is now ours, even in our absence. The intake line, the pump, the pressure lines, the toilets, even the drains must not be allowed to freeze with water in them.

PROS AND CONS OF KEEPING THE HEAT ON

The simplest method of looking after the inside plumbing in colder climes, and the obvious solution for ruralists, is to keep the heat on. For cottagers, this may sound like a decadent cop-

out, but if you're visiting the cottage every weekend, it can make economic sense. Any structure possesses thermal inertia, the more mass to the structure, the more inertia. When it's cold, the structure resists warming; conversely, when it's warm, it resists cooling. Therefore, if the structure is well insulated, maintaining heat in the building during short absences may consume less energy than what is required to reheat a structure left unheated. The key is to correctly install insulation and eliminate drafts while still allowing for ventilation. These topics are beyond the scope of this book, but there is no shortage of good information on the topic, much of it direct from government sources.

The problem with heat left on when you're away is that, in most of its permutations, it necessitates a reliance on the electric company. This is undoubtedly a gamble – one lengthy power outage could burst pipes, pump, and fixtures, subsequently flooding the cottage when the heat comes back on. Power outages are not uncommon in rural areas. If you don't feel comfortable with the gamble, have a trusted year-round-resident neighbour keep an eye on your place when you are away to minimize the risks.

PLUMBING FOR WINTER

A centralized plumbing layout works best for cottages doing winter duty. And, bonus, an arrangement where the kitchen, bathroom, and pump room are placed back to back to back saves money in supplies and facilitates easy draining. It also allows the option of heating only those spaces housing the plumbing. And you can shrink the heated spaces even further, tucking the pump into a bathroom closet or similar cubbyhole – about the size of a pump house, say. (See Chapter 3.) Then insulate that space – too much insulation doesn't exist – and place a few big rocks (or concrete blocks) in the corners to act as heat sinks. An insulated pump room also transmits less noise beyond its walls. Leave a single 60-watt light bulb on in the room and that space, and whatever's in there with it (such as mice), will usually stay above the freezing mark,

even during short power outages. But light bulbs can burn out, particularly in rural areas subject to power surges and power fluctuations (a good reason to only buy bulbs rated at 130V, not 115V, as the filaments are stronger). The other problem with this plan is that incandescent light bulbs are slowly being replaced with compact fluorescents, which don't emit very much heat (normally a good thing). So, instead of lighting, opt for a single, thermostatically controlled, 500W electric heater, preferably of the type specifically designed for pump house duty (and therefore better suited to being left unattended all winter in a damp environment). Also, go for a 240V version, then power it at 120V (depending on the design of the heater, you may have to change the plug to match a 120V outlet). Not only does this convert it into a 250W heater, which is more than enough to heat such a space, and as the heating element was designed for twice that voltage, it's likely to have a longer life operating at half load. But remember, the rest of a cottage water system will still have to be put into storage between visits unless, of course, you don't use it, getting your water only from the pump room in the winter.

THE OUTSIDE LINES

Whether the water source is a lake, river, well, or reservoir, the greatest challenge to keeping the water flowing in frigid weather is the line in. Often, it sits exposed to whatever the climate or humanity care to throw at it. Which is why, centuries ago, cities and most ruralists chose to bury this pipe underground below the frost line. The frost line is the depth below which the earth doesn't freeze. In most northern states and Canada, the frost line resides about 3'–5' (1–1.5 m) below the surface. It's possible, however, to artificially lower and/or raise the frost line.

CAPITALIZING ON NATURAL INSULATION

The earth above a pipe acts as an insulator. Insulation works by trapping millions of tiny air pockets within itself, making it difficult for the

air to move around and swap heat for cold. This is true regardless of the insulating medium, whether it be fibreglass batts, expanded polystyrene, wood, snow, or dirt. If we compress any of these materials, the insulating properties are diminished. How do we compress dirt? Driving over it with the family minivan is a good method, though even the weight of our feet tramping over it is enough the “push” the frost line downward. Therefore water lines, both incoming and drain pipes, should not run under driveways or pathways. If there is no alternative, bury the line deep enough to compensate for the lost insulating factor above. Or avoid tramping over the area during winter months.

INCREASING THE INSULATION: BUILD A STYROFOAM BOX

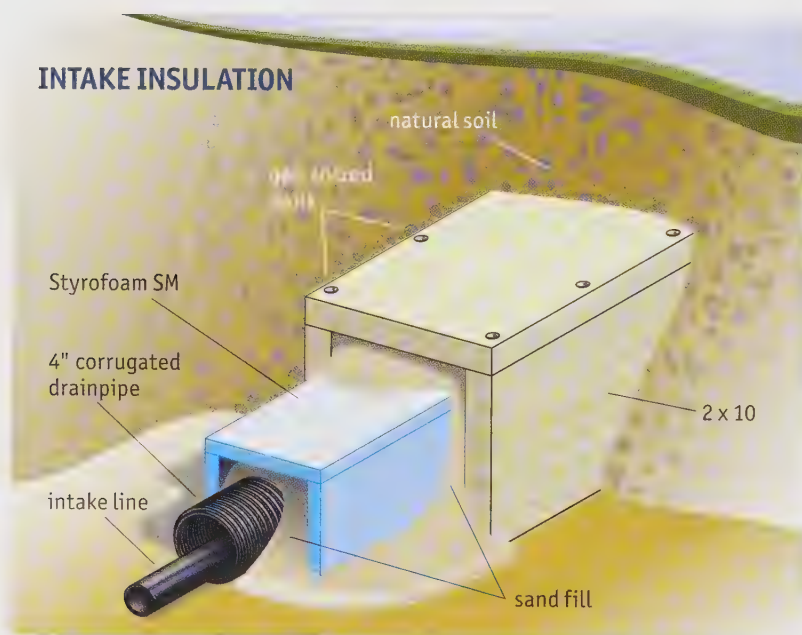
Snow makes a pretty good insulator – hard to beat the price – but it’s easily compressed (see Chapter 7 for winter cautions related to septic beds). One of the best insulators for under-

ground applications is 30-psi-rated Styrofoam SM (a closed-cell extruded polystyrene manufactured by Dow Chemical). As a guide, 1" (2.5 cm) of SM is equivalent to about 1' (30 cm) of earth. Because the heat of the earth can escape both upwards and sideways, it’s necessary to insulate the top and sides of the pipe, building an upside-down U-shaped box around it, using two of the lengths for the sides of the box and the third for the top.

If the route of the pipe is subterranean, one layer of SM on the sides will usually suffice, but more can be added to the top, these additional layers being the full 2' wide to increase protection. The incoming water line running from our spring to our home passes over a chunk of bedrock that restricts burying the line to a depth of 2' (60 cm) at that point. Since the frost line in our area is 4' (1.2 m) deep on average, 2" (5 cm) of SM would do the trick; however, we ran the pipe under a pathway (to avoid uprooting trees), so we added another 4" (10 cm) to the SM blanket. If the pipe runs close to the surface of a driveway, a U-shaped box of 2" x 10" lumber nailed together around the SM box will protect it from compression.

Because water conducts heat faster than air, if the soil is very moist, you’ll need to increase insulation thickness still further.

Here’s another trick, permitted in most jurisdictions: Put the intake line in an outer sleeve of 4" corrugated drain pipe. (See Chapter 4 for installation tips.) The sleeve prevents rocks or sand from caving in around the pipe, making it possible to remove it from its underground lair if repairs or replacement are necessary, and then reinserting it without having to dig up the entire intake line. The surrounding air space also acts as an insulating buffer zone. Waste lines running to septic systems or grey-water systems are usually rigid ABS or PVC plastic pipe, and therefore cannot be pulled out of any sleeve for service, so shield these pipes with U-boxed boards or culverts for protection under driveways, parking areas, and the like.



Subterranean freeze protection:

Physical protection and a layer of insulation keep intake lines warm and safe. Running poly lines through oversized drain pipe allows easy removal for repair.

THE INS AND OUTS OF AN AIR VALVE

An air valve, or a two-way bleeder valve, is positioned perpendicular to the intake line, using a T-fitting the same diameter as the line, the two ends of the T connected to the intake line, the other aimed perpendicular and upright to the line. To the upright end, attach an in-line ball valve, then the air valve, with about a foot of pipe running up from that to catch any drips of water that might escape past the valve just before it closes. Air valves can be hard to find but, fortunately, adapting the readily available check valve to the task is easy: simply remove the valve's spring, replacing it with a short spacer if required, and then install the valve upside down so that the pressure of incoming water will close it. When the pump stops, the check valve located just before the pressure tank stops the water in the building from flowing back, the drop in pressure in the intake line letting the modified check

valve fall open to let the air back in, which in turn lets the water drain out the bottom of the line.

The spacer may be necessary because without it some converted valves tend to get hung, refusing to shut, and the water just keeps on coming. The spacer shortens the distance the valve needs to travel before it shuts, eliminating hang-ups. As the thickness of the spacer (or even the need for one) will vary depending on valve weight (a factor of size and material), you may have to experiment a bit to get the right thickness, but as a guide a 1/4" spacer generally works for a 1" brass valve, while a 3/8" spacer is good for the average lighter 3/4" valve. At least 99% of the time, anyway.

The in-line ball valve allows you to close off the route to the air valve in warmer weather, eliminating the added load on the pump of filling an empty drain-back system when it's not necessary.

Lay the pipes (sleeved or unsleeved) in place, prop up the two side pieces of SM, and dump sand around both sides of the SM side-walls (don't tamp it down, this only forces out the air pockets). Level the sand to the top of the SM, place the upper layer (or layers) of SM over the side walls, and cover the whole mess up (altering this sequence if necessary to include any U-shaped wood protection).

Pipe doesn't have to run underground to get this favoured treatment. A mound can be built up over surface-installed pipe. Keep the slopes gentle and plant something with a good root structure (like grass) on top to prevent erosion.

Where ice conditions permit, an intake line can be left in a lake or river all winter. In some jurisdictions, however, it can't be buried into the shoreline. (Check with local authorities: Fines can range up to \$300,000 for some lakeshore disruptions.) Wherever an intake line has to enter the water above ground, use a section of rigid 4" ABS drainage pipe for a sleeve at the shoreline. ABS is less likely to be crushed by ice than corrugated drainpipe. The problem with surface lines at water's edge is that any attempt to insulate can

easily be torn apart by winter's wrath. Depending on the size of the intake line and the size of the sleeve, it may be possible to wrap the intake line in polyethylene foam pipe insulation sleeves before sliding it into the outer ABS sleeve.

If using a submersible pump, you will also want to protect the electric wiring at this point, running it through the same ABS sleeve or a smaller diameter ABS sleeve of its own.

SELF-DRAINING OR HEATED? OTHER OPTIONS FOR ABOVE-GROUND LINES

Two other options for above-ground applications are self-draining intake lines and heated lines. The solution best suited to your situation may involve a combination of insulation, self-drainage, and electric heating cable.

A self-draining intake line, or drain-back system, allows water to flow to the building and fill the pressure tank before automatically draining back to the water source, leaving the intake line empty. This cycle repeats each time the pressure switch on the pressure tank signals the

pump to start delivering water. The essential ingredient here is speed – the water must drain out fast enough so as not to freeze. For this to happen, the slope of the line must be increased from the normal $\frac{1}{4}$ " per 1' (2 cm per 1 m) to a minimum slope of 1 in 13. In other words, whether you are measuring in metres, feet, chains, or shoelaces, for every 13 units of measure the line runs horizontally, it must drop a minimum of one unit vertically. If it drops two, so much the better. Also, the slope must be continual, meaning that the entire length of the line must be without any dips and valleys that will trap water. And, because the empty intake line must be filled quickly every time the pressure switch kicks in, most pumps used to draw water into the house or cottage, like piston pumps and jet

pumps, won't work for this application. A submersible pump, however, will.

For the water to flow back down the intake line, the check valve usually mounted on the top of the submersible must be removed. This creates a problem: Most manufacturers strongly recommend that a check valve be installed either on the pump itself or in the line within 25' (7.5 m) of the pump. Without this valve, the water will rush back down the line (which is what you want for a self-draining system), spinning the submersible motor and impellers up to three times the designated operating speed. In reverse. Obviously, this isn't the best thing one can do for the motor, yet many plumbers are installing submersibles in this manner without apparent problem. In fact, two of the pump manufacturers I contacted regarding this dilemma stated that while they didn't necessarily approve of the practice, they still lent advice on how to make it work.

First, use only a top-quality submersible pump. Lesser models are more likely to wear and break. At the top of the intake line, install a check valve immediately before the pressure tank to prevent water in the indoor portion of the system from draining back out the intake line. Just before the check valve, install a two-way air bleeder valve, also known as an air valve. This valve provides a means for the air to escape out of the line as water is being pushed up to the building, and lets air back into the line to hasten the draining of water back down to the source. Without this air valve, the pipe could burst. (To convert a check valve into an air valve, see p. 153.)

The other crucial element of a self-draining system is the pressure tank. It must have sufficient drawdown (the amount of water drained out of the tank before the pressure switch activates the pump) to permit the water in the intake line to empty before the pump is asked to supply more. Should the signal be given for the pump to start while it's still spinning backwards, odds are very good that the pump shaft will snap under the strain. How much drawdown is enough? That depends on the model of tank, the pressure your system is operating at (higher pressure equals lower drawdown) and the size and length

ICE PLUGS IN DRAIN-BACK SYSTEMS

When a drain-back system that uses heating cable at water's edge is left unattended for a week or so, and not used on a daily basis, the intake line can still freeze when temperatures drop. Typically, the system will work fine when first used after an absence. A while later, maybe next morning, no water. Outside, when you wiggle the intake line (the normal first reaction), you hear ice cracking inside. But the pipe is supposed to be empty. What happened?

Contrary to gut feelings, neither the heating cable nor drain-back system failed. Because the heating cable must enter the intake line above the high-water line (typically via a special T-fitting), a short distance of heated, empty pipe remains between the fitting and the waterline. As the cable heats the water, warm, moist air gathers in that empty space, this air slowly migrating up the pipe to condense on much colder, unheated walls within 6'–10' (2–3 m) of the T-fitting. There, it gathers, gradually closing in on the pipe to form a plug. The first time the pump starts, it fires that ice plug up the pipe with the force of a water canon, the plug typically following the air ahead of it up into the air valve, blocking or hindering that valve's ability to let air flow back into the pipe when the pump stops. So the water in the pipe either stays there or drains out so slowly that it freezes. Therefore, no more water running to the taps.

To reduce the odds of this occurring, insulate the intake line above the heating cable entry point. Three sections of polyethylene foam pipe-sleeve insulation (18' or about 5.5 m) will discourage that warm, moist air from freezing on the walls of the pipe, extending the safe period of any absence.

of intake line. It takes about one minute for 100' (30 m) of 1" intake line to empty on a 1:13 slope, so the pressure tank must have enough draw-down to supply the house or cottage for that period regardless of how many toilets are flushed, dishwashers started, and showers turned on. Your plumber or plumbing supplier should be able to help you choose a tank of the correct size based on your projected water consumption and the length of the intake line.

One alternative for those reluctant to go against the wishes of pump manufacturers is to drill a 1/16" hole in the intake line just above the pump's check valve. Although that hole seems very small, according to the plumbers I consulted, it's more than adequate to drain the water back down out of the pipe, and its diminutive size means no noticeable loss in pressure when the pump's working. However, that tiny hole can clog easily. (Keen readers will recognize some similarities here with the deep-well traditional hand pump described in Chapter 3, a point in favour of the "nothing new under the sun" crowd.) If this should happen, you won't know about it until the line freezes. Boy, when it comes to gambling, Las Vegas has got nothing on the lakeside winter waterline.

Yet the true Achilles heel of most self-draining intake lines is that the water will not drain past the level of the source water. And if the source is anything but a deep well, the water that remains in the pipe where the intake line meets the water source is subject to freezing, which kind of defeats the whole purpose of the drain-back system. Fortunately, there are two ways to cure this problem: either force all the water out of the intake line with compressed air or heat the short section of pipe where it meets the source.

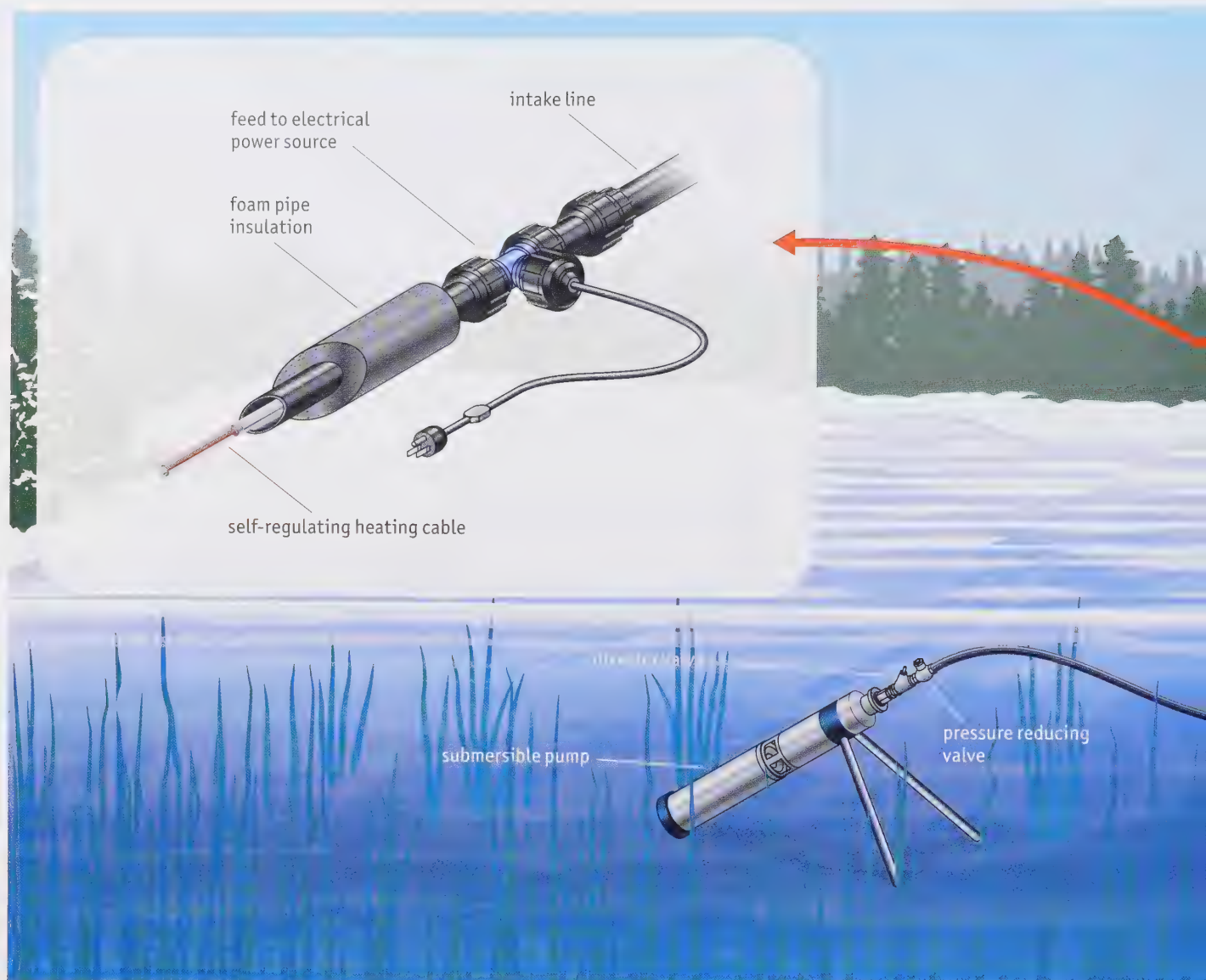
PUSHING THE WATER OUT UNDER PRESSURE

Remember the air in that self-draining pipe that needed to be pushed out of the pipe through an air valve to make room for the incoming water? Suppose, instead of ridding the system of that air, we store it in an auxiliary tank, and then use

that same air to push all the water back out again when the pump stops pumping, all the way back to the pump submerged below the waterline. Essentially, this is what a system manufactured by an Ontario-based company called Cottage Water Supply does. Actually, the company offers two drain-back systems, one that uses a short section of heating cable (see p. 158) at water's edge, and one that uses air to push the water out. Because water will absorb air, and pressure diminishes as its temperature drops, the air pressure in the system needs regular monitoring (the auxiliary tank has its own pressure gauge), and top-ups when necessary (see Chapter 4). The only electricity consumed is by the pump.

With either of the company's systems, the check valve in the pump is removed and replaced by a diverter valve. To envision how this valve works, picture a swinging-gate at the fork of a Y, the bottom leg of the Y connected to the pump, one of the upper legs leading to the intake line, the remaining leg exiting directly into the source water (lake, river, well, etc.) When the pump starts up, water pressure pushes the gate out of its way, the gate swinging around to block the exit as it opens the path to the intake line. When the pump stops and the water in the line begins to drain back, the gate swings the other way, closing off the route to the pump while opening the exit to the source water. A pressure reducing valve located just above the diverter moderates the returning water's flow, making it easier for the gate to swing down, thereby opening the exit. (These specialty valves are sold individually if you want to build your own system.) Where the drain-back systems differ is up top by the pressure tank, one system letting the air escape and re-enter the pipe via an air valve, the other capturing that air in an auxiliary tank, then using that air to force the water back out through the diverter valve.

With the compressed-air system, most of the section of intake line lying underwater is full of air much of the time. Therefore, it must be well anchored to prevent it from floating to the surface and perhaps getting snagged in the ice. Yet because even the tiniest of air leaks can result



Underwater details of a self-draining system:

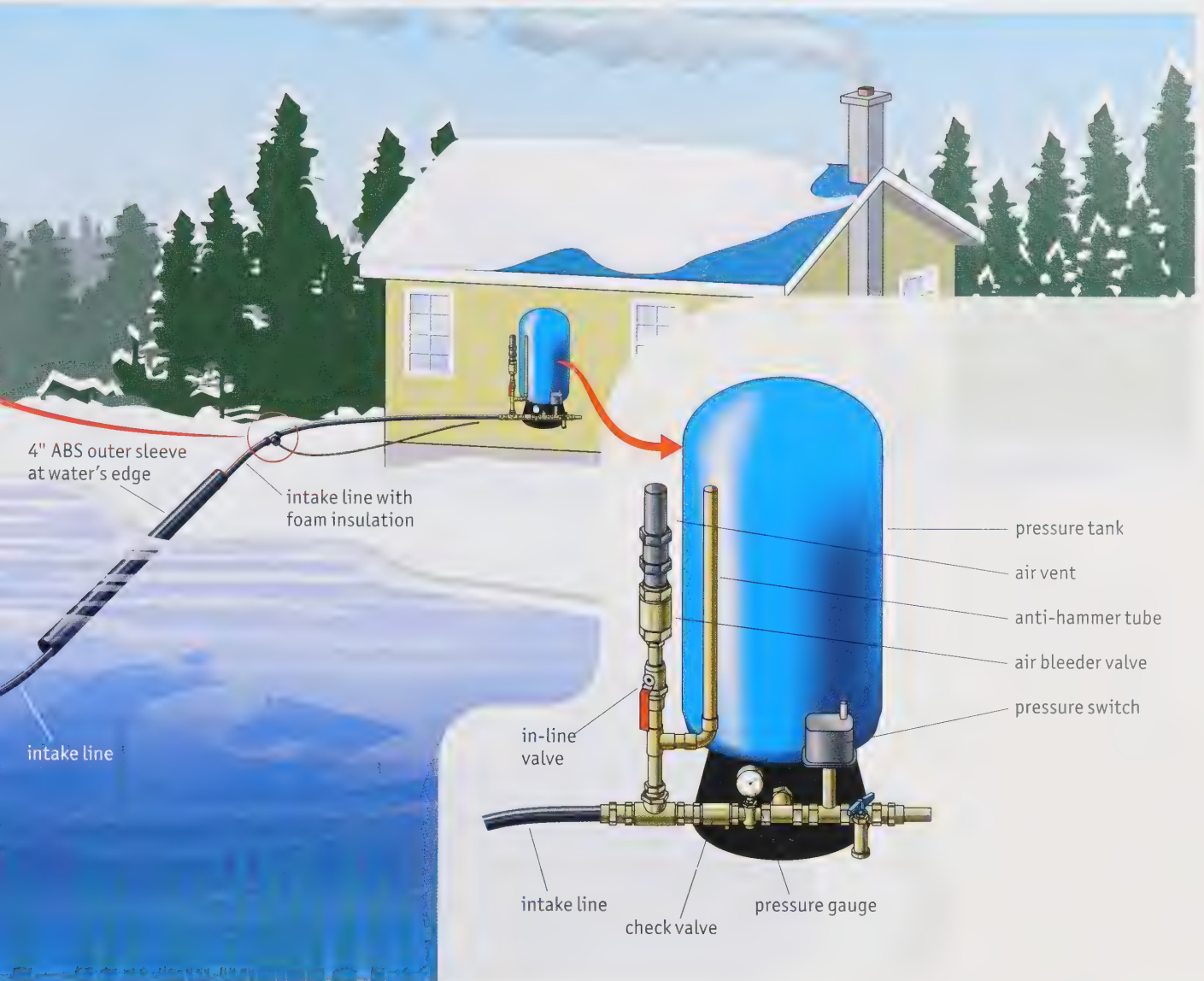
After filling the pressure tank, the water in a drain-back system automatically flows back to the source, leaving the intake line empty – and freezeproof. At the pump, the check valve is replaced with a diverter valve, which redirects returning water to the source to protect the pump's motor and impellers from spinning backwards.

in that crucial section of pipe filling with water, installing a heating cable in it is cheap insurance against disaster, turning the cable on only if water should sneak in and freeze.

There are two basic types of electric pipe heating cable: conventional heating cable and self-regulating cable, with each of these categories further divided into cable that is wrapped around the exterior of a pipe and cable that is inserted into a pipe.

CONVENTIONAL HEATING CABLE

Conventional heating cable works on the same principle that the majority of simple electric heating devices use: electricity is passed through a heating element, which provides a fixed amount of resistance to the flow of electrons, resulting in internal friction which in turn causes the element to heat up. By attaching a thermostat to



Topside details of a self-draining system:

An air bleeder valve allows air to escape from the intake line as it is displaced by incoming water from the pump. When the pump shuts off, the valve allows air back into the line to speed its drainage back to the source. Because water will not drain much past its source level, intake sections near the shore should be insulated and heated.

the element's electrical feed, we can control how much electricity flows through the element over a given period of time. A thermostat turns the power feed off or on as the temperature rises or falls in order to maintain preset levels (an action called duty cycling).

The location of the thermostat's sensing unit is very important for accurate temperature control. As an illustration, if the sensing unit of an oven thermostat were placed in the refrigerator,

the oven's heating elements will be instructed to work overtime to overcome the cold registered by the misplaced sensing unit. Obviously, the oven will get much hotter than what the setting on the thermostat called for. Goodbye, Sunday-night roast, hello, smoke detector.

Correct placement of an oven's thermostat sensing unit is an easy matter – stick it in the oven. Unfortunately, life is not that simple with conventional heating cable. While the oven is a

small, controlled environment, an outdoor pipe may have to cope with a variety of temperatures over its length. For instance, at water's edge, the temperature of an intake line can be close to the freezing mark; a few feet up from there, perhaps where the line runs out in the open over bedrock, the temperature can fluctuate wildly due to atmospheric conditions (which include cooling from the wind and heat from the sun). The section running under the dwelling, meanwhile, could rise to well above freezing when the building is heated during visits. So where do you put the sensing unit? You compromise and put it somewhere between the fridge and the oven and hope for the best.

A pipe heated by conventional cable must always have water in it. Any loss of prime – as a result of foot-valve failure, for instance – and the pipe could overheat to the point of meltdown. The problem is that the amount of heat generated by a conventional heating element, like this cable, is constant throughout the length of the element. It is unable to compensate for varying conditions, such as the sudden loss of water.

Conventional heating cable is also difficult to insulate without causing overheating. And it's an expensive way to warm a pipe: Heat tends to migrate to the coldest regions, so much of the cable's energy is therefore lost to the surrounding air, which is like tossing dollars to the frigid wind. For all these reasons, if you decide that an electric heating cable is the route to go, pry open the wallet a little further and install self-regulating cable.

SELF-REGULATING HEATING CABLE

Right up front, self-regulating cable costs you about twice as much as conventional heating cable. What do you get for the extra bucks? You get a cable that contains two wires separated by a thin layer of temperature-sensitive conductive material. As the temperature drops, resistance to the flow of electrons through this conductor increases, automatically creating more friction and therefore more heat. Conversely, as the tempera-

ture rises, resistance decreases and less heat is generated. This happens continuously (automagically?) over the entire length of cable. It's like a having a million sensing units, each attached to its own tiny heating element.

Unlike conventional cable, a self-regulating cable will not overheat in an empty pipe. This makes it the only choice for heating self-draining intake lines at water's edge, where conditions inside the pipe can range from freezing at the water line, to above freezing below the water line, to extremely cold and devoid of water above the water line, all in the space of a few feet. (See box on p. 154 for additional tips on keeping this section of pipe from freezing.)

Regardless of which type of heating cable you choose, and how much of the intake line you heat, the water inside the pipe can still freeze. The power can go off, leaving the water to fend for itself. And if the pipe is uninsulated and sitting on open ground, at about -15° F (-25° C) most heating cables are no longer able to create sufficient heat to offset the extreme cold. Then there's the wind. Wind cools off the water in a pipe the way it cools off the water in your car radiator. As the wind robs heat from the pipe, the cable's ability to cope is further reduced. Just getting the pipe out of the wind helps, but insulation it is what really makes a difference.

THE ADVANTAGES OF INSULATING

Because of its ability to adjust heat output based on a very localized demand, self-regulating cable allows you to insulate the pipe without fear of a meltdown. This is perhaps the greatest advantage of this type of cable. Such systems, out in the open with only ½" polyethylene foam pipe sleeve insulation, are being used in Canada's Northwest Territories in temperatures that regularly drop below -50° C (that's bloody cold in Fahrenheit). As a bonus, when pipes are insulated, if a power failure should occur, heating cable or not, freezing is delayed since the water then retains its heat for much longer periods. Insulation also keeps the water cooler in summer. And of par-

ticular appeal to my world-renowned parsimonious nature, insulating a heated water line results in serious savings on the electrical bill.

And it gets even better. A central thermostat can be hooked up to a self-regulating cable as a master control over those “million sensing units.” According to one manufacturer, with this thermostat set to about 45° F (10° C), its sensing unit tucked in between the outer pipe wall and the insulation, electrical consumption can be as little as 10% of the energy required to operate an uninsulated conventional heated line. Even if we factor in marketing braggadocio, and this setup only achieves half those savings, that’s still worth bragging about. And while you may need a dedicated 240V circuit for conventional

heating cable longer than 75' (23 m), most self-regulating cable gets by with the standard 120V circuit. And for folks off the electric grid, Heatline (see p. 160) makes the Kompensator, a self-regulating heating cable designed for 12V or 24V power supplies, such as those generated by solar or wind power.

IN OR OUT: WHERE SHOULD THE CABLE GO?

Heating cable can be wrapped around the exterior of a pipe or inserted through it. While exterior cable can be used for intake lines, it’s more susceptible to damage from nature and humanity. Therefore, interior cable is the better choice

THAWING FROZEN PIPES

Despite all your efforts, it’s possible that water left in pipes may still freeze. Electricity gets cut off in a storm, no one is around to notice, the temperature drops, and the next time you ask a tap to deliver, it fails to answer.

For self-draining intake lines, the trouble spot lies at water’s edge. Fortunately, when water freezes and expands at this point, any unfrozen water lying below the expanding frozen bit is pushed out the diverter valve or drain hole located just above the pump in deep water, well below the ice layer. Above the expanding frozen bit, the empty intake line allows the air to move upward inside the pipe as the ice creeps up behind it. When the electric heating cable comes back on, it will melt the ice and water will once again flow through the line. At least most times. Plastic, such as a polyethylene intake line, has some elasticity to it, allowing some outward expansion without visible damage. However, poly pipe is subject to fatigue over time and hairline cracks may develop. (See Chapter 4 for repairing leaks.)

Speaking (parenthetically) of repairs, avoid joints in the line whenever possible and, in particular, near the water’s edge. Joints are usually the weakest link in the system and, as a result, the spot most likely to be damaged in a freeze-up.

For interior plumbing, there are a few tricks to thawing frozen pipes. First, open any taps at both ends of the frozen section. This allows steam and air to escape without putting more pressure on the beleaguered pipe. Next, heat the pipe slowly, starting at the point closest to one of the taps, working back as the ice thaws. If you start in the middle, steam pressure will build and, unable to get past the ice to the open tap, could burst the pipe.

Copper or steel plumbing can be heated with a propane torch, but be very careful of the flame in a confined area. With all your attention devoted to the job at hand, you may not notice that floor joist directly behind the pipe as the flame scorches it. Cold, wet rags placed over vulnerable areas will discourage the flame from heating up anything but the pipe. A hair dryer will also work on metal, and on plastic pipes too, but extra caution is advised in heating plastic. (Don’t even think about heating plastic with a torch.) Hot, damp towels also work well in thawing plastic pipes, assuming you’ve got some means of wetting and heating towels.

Once you and the pipes are thawed, check the system for leaks and then, if possible, correct the problem that caused the pipes to freeze in the first place after filling the kettle for hot drinks.

for intake duty. Also, even when the pipe isn't insulated, interior cable loses less heat to the world around it than exterior cable does.

Interior heating cable can be purchased pre-installed in poly pipe or separately, in a kit, to allow installation into an existing intake line.

In theory, a cable running inside the intake line can increase head loss, though in practice these concerns appear to be unwarranted. Nonetheless, as a guide, 100' (30 m) is considered the maximum for 1" line housing heating cable, while 1¼" line is good for about 300' (90 m). Use only cable that has CSA, UL, or similar approval for use inside a water pipe. Cable not approved for this specific application has not been successfully tested by a recognized agency for off-gassing and toxicity levels, and should never see duty inside any potable-water pipe.

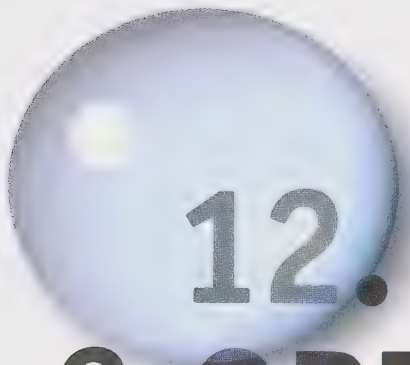
Interior cable should not be used for waste lines because it will restrict the flow of sewage. It also makes unplugging a sewage line expensive, difficult, and a downright gucky job. (Picture pulling 100' of dung-dipped cable from your waste pipe. Actually, don't, it's too revolting to picture.) If a sewage line needs to be heated – where it might run above ground from a raised dwelling to a raised septic bed, for instance – use heating cable designed to be wrapped around the exterior of the pipe. Exterior cable can also be wrapped around the water box of a pump (but not the motor) if the pump is located in an unheated space. (This can be done with both water or sewage pumps.)

HEATED RECOMMENDATIONS: GO THE SELF-REGULATED ROUTE

Whether heating the entire intake line or just the portion at water's edge (using a drain-back system for the rest), go with self-regulating cable tied into a central thermostat, with the pipe well insulated. This system provides optimum protection and is economical to use. Heat-line Corporation does a particularly nice job of putting together a user-friendly package that requires no special skills to install. Everything is designed to

simply plug in – the cable into a standard electrical outlet (the plug has a built-in GFCI), the company's thermostat into a standard outlet. Even the pipe, which you can purchase with cable and insulation pre-installed, essentially plugs into an existing pipe leading to the pump or pressure tank. The assembled cable, which runs through a Philmac connector (see Chapter 4) custom-made for Heat-line, can be purchased separately for retrofitting, as can the company's pipe sleeve insulation, a ¾" thick closed-cell polyethylene foam manufactured to fit either 1" or 1¼" pipe.

As an aside, if you have a deep-well jet pump that needs protection from freezing, you've got two lines to heat, which doubles both your initial investment and your operating costs. Bury the line or sell the pump and get a submersible.



12. CLOSING & OPENING UP

Rituals for a seasonally adjusted water source

Draining and
storing lines

Shutting down
the pump

Where to use
antifreeze

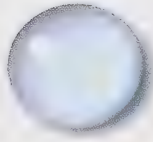
Tanks and
appliances

Winterizing waste
lines

Flushing
antifreeze

Priming the pump
(Max's amazing
easy prime)

Seasonal guides:
The flow chart and
the unflow chart



ALTHOUGH MANY COTTAGES are becoming more like second homes, making the traditional role of the cottage as a seasonal vacation residence a little fuzzy, most cottagers still pack it in for the winter months. This has spawned the twin rituals known as closing up and opening up, providing emotional and labour-intensive bookends to the cottage season. These are perhaps the only two times cottagers with running water envy those without.

PRINCIPLES FOR A SUCCESSFUL CLOSING

It's the terminology that troubles me most about closing up the cottage. "Closing up" makes it seem so final – like we're not coming back, so who cares if the chores aren't done? To my mind (a warped one, admittedly), putting the cottage

into storage seems infinitely more appropriate. The word storage carries with it the implicit notion that the period of disuse is only temporary. The cottage, the boat, the memories – no longer closed, but preserved for future service.

Yet it has been my observation that often cottages are neither stored nor closed up but instead abandoned. When the delinquent owner returns, miracle solutions are sought to erase the inevitable degradation caused by weather and time. Unfortunately, there aren't any miracle solutions. If cottagers want to be up and running with a minimum of fuss in the spring, the cottage needs to be stored properly before putting it to sleep for the winter. And this is especially true for the cottage plumbing system.

DRAIN EVERYTHING

The basic rule is: Protect the system from freezing. Most liquids, when they become solids, contract and become more dense. Water, however, is

one of nature's weirdos. When it solidifies (becoming ice), it expands and becomes about 8% less dense. That's why ice floats. And that's also why ice needs more room than unfrozen water, about 10% more actually. This expansionary policy can put tremendous pressure on the walls of any container, pushing those walls outward. If the walls lack elasticity, they break. From reinforced-concrete cisterns, to cast-iron water boxes on pumps, to plastic or steel pipes, to ceramic toilet bowls, nothing is immune to the power of ice.

The best way to ensure that water will not freeze, expand, and force its way out of or through some cottage treasure (like the indoor toilet) is to completely rid the cottage of water. In other words, drain everything.

ANTIFREEZE GUIDELINES

Some folks top up the system with antifreeze. While there are some spots where this may prove to be the best option (specifically, places that are a pain to drain, the toilet trap being the principle villain), understand that antifreeze does not prevent water from freezing; it merely lowers the freezing point, usually by interfering with the formation of ice crystals. If the temperature dips below this altered freezing point, the water will freeze and expand. Most types of antifreeze (and cottagers, for that matter) deteriorate with age, thereby increasing the risk of frozen pipes and fixtures over the course of a winter. An empty pipe or fixture doesn't run these risks.

But of greater concern than antifreeze's ability to stave off the formation of ice is its toxicity levels. A mere taste of methyl alcohol, for instance, can cause blindness; a 30 ml (2 tbsp) slurp can kill. So if antifreeze is to be used in any part of the plumbing system, from water lines to waste lines, make sure it's propylene glycol, also known as RV antifreeze. Propylene glycol is nontoxic to humans, an approved food additive, a constituent of many cosmetic creams, and a pretty good antifreeze. Used in the quantities recommended on the label, it will not harm humans or even the bacteria in the septic system. Any other type of antifreeze can. However, at the

time of this writing some conflicting evidence suggests that propylene glycol may be harmful to some pets, so for their safety, ensure that they don't have access to any antifreeze, regardless of type. (For instance, if adding RV antifreeze to the toilet, close and put a weight on the lid.) And do not confuse propylene glycol with ethylene glycol, which is the stuff we add to a car's radiator, nor with windshield washer antifreeze, nor any other antifreeze. If you can't remember the chemical name, look for the RV and nontoxic indications label on the container.

STEP BY STEP: DRAINING YOUR SYSTEM

REMOVE AND STORE THE INTAKE LINES

Plastic and metal, the stuff pipes are made of, become brittle in the cold. This is particularly true of the cheaper grades of poly pipe (another good reason not to buy the wretched stuff). Regardless of type or grade, any pipe's susceptibility to damage is increased by cold weather, particularly if it's exposed. Then perhaps it's no surprise that the pipe voted most likely to fail over winter is any intake line taking an overland route to the cottage. Even if drained, a pipe and any connections left out under the snow are at the mercy of snowmobilers, nordic skiers, hikers, and animals out for a stroll. (A deer's hoof can easily put a hole in cold and brittle poly pipe).

Then there's pack ice. Technically speaking, pack ice refers to chunks of frozen salt water that drift about in ocean currents and winds, so you wouldn't think it would be much of a problem at those cottages situated between polar circles. However, come spring the ice on many lakes and rivers mimics the reprehensible conduct of pack ice, piling up on shorelines, driven there by the force of winds and currents. So up our way we call it pack ice. Nobody seems to notice the lack of salt or penguins.

With or without the threat of pack ice, should your cottage's intake line run above ground to the lake, river, or well, taking the line up and storing it some place out of harm's way is your best buy in "easy opening up" insurance. If done correctly, the job involves no annual cash expenditures and, more importantly, it greatly reduces the risk of having to locate and repair weak joints and hairline cracks in the line, a task that often melds frustration and tedium into a ruined weekend.

STORAGE STRATEGIES

Storing the pipe entails disconnecting it from the pump, then dragging the pipe out of the lake or river. If possible, storing pipe in long, straight lengths is best, but unless the cottage is equipped with its own bowling alley, this may not be possible. So usually poly pipe is rolled up in a coil for storage. There's no way to make this job easy, but quick disconnect fittings, such as offered by Philmac and Hanflo – because of their ease of use and leak-proof design (see Chapter 4) – will at least make the task less arduous, and may permit storage in shorter straight sections. If the incoming line is metal, switch to poly if local codes permit. Metal corrodes and, besides, it's a heck of a thing to roll up for storage, although nobody told pack ice it's not easy to bend.

The moment you disconnect pieces of incoming line from each other or from a device like a pump or pressure tank, plug the open ends. The amount of dirt, sand, small stones, and rodents that can sneak into an open pipe end when you aren't looking has got to rank as one of the great aggregate wonders of all time. Naturally, this trespass won't become apparent until next spring when the pump won't prime and you spend a weekend or two looking for leaks in the line before finally getting the nerve to take apart the pump, at which point you find the injector or impeller plugged with grit. A plastic bag wrapped several times around the open end of a pipe, then secured in place with black electrical tape or a tie-wrap, is usually sufficient to keep debris out.

LEAVING WELL ENOUGH ALONE

If pack ice has not historically been a problem at your cottage, and you don't mind gambling that history will continue to repeat itself, it may be possible to disconnect the line at the shoreline (perhaps at the T-junction mentioned in Max's *Amazing Easy Prime*, p. 168), leaving the end with the foot valve – or a submersible pump if you went that route – to winter under water. If the line to the lake or river is buried, or even placed inside a protective outer shell (see Chapters 4 and 11), you may be able to leave the entire line in place, drained to the surface of the water source. If you do, it would be wise to increase the amount of anchorage to discourage the ice from tampering with the line. Try running the line through several concrete blocks, maybe one every foot or so, keeping in mind that anchors mean little to ice. Use only the best in poly pipe, and don't call me if it breaks, for the antics of ice are unpredictable.

Of course, the beauty of leaving the incoming line where it lies is that you don't have to struggle with sedentary sections of pipe. But if the line is subject to freezing, it must be rid of water. Ideally, it should be installed to allow gravity to do the draining. For this to happen, the incoming line must have sufficient slope down to the water source (about $\frac{1}{4}$ " per 1' of horizontal run, or a 2 cm drop per 1 m, minimum). Then, to drain the line, all you have to do is turn off the pump, open a tap located just before the foot valve (see below), open the taps in the cottage, and let the water drain out of the lines back down to the surface of the lake, river, well, or wherever your water source may be. Nothing to it. The water still in the line underwater will likely freeze to the same depth of the ice around it, slowly migrating up and down the pipe without causing damage, but it will need to thaw in the spring before water can flow again.

A friend of a friend of my uncle's neighbour's daughter's boyfriend (it's important to keep track of such things) doesn't even bother with a foot valve, instead opting for a check valve located on

the intake line just before the pump. The water is drained out of the cottage pressure lines through the drain tap located at the lowest point (at the pump), then the check valve on the intake side is disconnected, letting air into the line as the water flows back toward the lake. (If you're not using a submersible pump, taking a pass on the foot valve means you're going to need a pump with some tolerance for air; see Chapter 3.)

The crucial point with either method is that all the water in the line above the source surface must be removed, which is possible only when a water line has no peaks or valleys in the entire length of its run. If you have any doubts, force the water out (thus filling the pipe with air) using either a hand-operated diaphragm pump (see Chapter 3 again) or an air pig (read on). The diaphragm pump has the advantage of almost zero setup time, and it never runs out of air as long as someone is pumping the handle, and it's also good for moving air and water.

The air pig is a 5–7 US gal. (20–25 L) metal tank. It resembles the portable propane tank for the gas grill out on the deck. But instead of propane, it holds pressurized air, available at most service stations with the same hose you use to fill the car tires. In fact, an air pig, topped up, will fill about 2–3 of those tires. So it's an adaptable pig. To clear leftover water out of your lines, you will need to install a T-junction in the intake line a bit before the pump and an inline shut-off valve just above the T. On the open leg of the T, install another inline shut-off valve, then a reducer to bring pipe diameter down to 1/4", a threaded female-adaptor, and then a Schrader valve at the end (the same type of valve that's on your car's tires). Come time to empty line, follow the same procedure outlined three paragraphs above, then close the shut-off valve above the T, open the shut-off valve on the leg of the T, attach the air pig's hose to the Schrader valve and let the air push out the remaining water lying in the low spots. Whether using the air pig or the hand-operated diaphragm pump, you might want to conscript a volunteer to watch the opposite end of the pipe to make sure the reluctant water is leaving.

DEALING WITH INTAKE LINES FROM A WELL

Cottagers with wells and a buried intake line don't have to worry about pack ice pounding the plumbing. However, if the line is not buried below the frost line, which in the northern states and Canada ranges from 3'–5' (1–1.5 m), the line from the cottage to the well will still have to be drained. In a dug well, the easiest way to do this is with a T-junction and tap located just before the foot valve, though if the exit-leg of the T is higher than the water line, the line will not completely self-drain and the remaining water will have to be removed, either by forcing it out from the pump end or drawing it out at the T-junction. Again, it's tough to beat the hand-operated diaphragm pump for this kind of work.

After years of struggling with low-grade poly pipe each spring and autumn, my in-laws finally broke down and had a well drilled. Although the line to the cottage does not sit below the frost line, it does follow a gradual slope up from the well. At the end of the season, the well seal (or well cap) is opened and the pitless adaptor is hoisted up just enough to break the seal between the adaptor and the well casing, letting the water drain back into the well. Then the adaptor and well seal are replaced. Come spring, the submersible pump is started and the line fills with water. While this technique certainly has simplicity on its side, any time the well is opened there is a risk of contaminating the water. For this reason, some jurisdictions forbid such tampering with wells, while others may insist that the well be disinfected after each opening of the well seal. Also, in theory, this could put additional wear on the seal of the pitless adaptor, as it really wasn't designed to be a tap.

An alternative solution would be to install a T-junction and tap in the intake line just before it enters the well, using the hand-operated diaphragm pump again to assist with emptying the line. However, whether using the pitless adaptor or T-junction and tap, water will remain in the pipe from the designated point of draining, down to the foot valve (or the check valve on a

submersible pump). If this section of pipe is long, and exposed to winter's temperatures, it's at risk of freezing and cracking. If you aren't prepared to take those risks, the intake line must be withdrawn from the well, drained and stored. And if a submersible pump is attached to the end of it, that constitutes more heavy lifting than most folks would want to entertain.

EMPTYING THE HOT-WATER TANK

Shut off the power to the hot water tank before doing the same to the pump. This allows you to use up whatever hot water remains in the tank (which you've already paid to heat), maybe for a final dish wash. And because the pump will then refill the tank with cold water, the tank's contents won't be dangerously hot when it's finally drained. Draining of the tank not only prevents freezing, it also removes sediment once a year, which will prolong tank life. The tank should be drained after you have drained the pressure lines. (See below.)

To rid the tank of water, turn off the pump, attach a hose to the tank's drain tap, and lead the other end to a cottage storm drain or somewhere outside. (Overloading the septic system with water is not good practice at any time, but can be especially deleterious just before abandoning it for the winter.)

If the water seems to merely dribble out the tank, sediment may be restricting the drain tap, you can sometimes solve this problem by poking a thin wire up into the drain tap. If the blockage won't clear, you may have to remove the tap and clean it.

DRAINING THE REST OF THE SYSTEM

With the pressure lines installed as suggested in Chapter 4, turn off the pump, open all the taps and in-line valves, flush the toilet a couple of times to empty most of the tank (the residual water in the tank will need to be mopped up with a rag), and let gravity drain the water out of 99%

of the system. (There are no 100% guarantees in life.) If your cottage is fed by a centrifugal pump (like a jet or submersible) and there are no check valves in the lines (or bypasses with in-line valves installed to permit the water to drain around the check valves), this auto-drain method can be used to empty the entire water system, including pressure lines and the incoming line all the way back to the water source. Folks with other types of pumps (like the piston pump or centrifugals with check valves) will have to drain the incoming line (from pump to foot valve) and the inside pressure lines (from taps to pump) separately. Where water and gravity fail to cooperate, such as when an intake line follows the path of my stock portfolio (mostly down, but with the occasional upward trend), you'll have to blow the water out with air, using either the diaphragm pump or an air pig. Plastic pressure lines are the most susceptible to sagging between support clamps (the more frequent the clamps, the less sag) yet, as mentioned in Chapter 4, some plastics such as PEX will tolerate a freeze-up or two, though none will survive repeated freeze-thaw abuses.

Bladder and diaphragm pressure tanks will self-drain with the rest of the system. Older style plain tanks in which air and water share the same space should be drained through the drain plug provided to remove any last vestiges of water after the rest of the system has been drained. For those who don't know which type of tank they own, the plain pressure tank has a drain plug at its lowest point. Bladder and diaphragm tanks don't have, or need, drain plugs.

All water treatment devices also need to be drained. Because they differ so much in design, a manual is a real help here. If you left the manuals back home in the city, look for drain plugs. None of the water contained in any purifier – especially large capacity tank filters – should be drained directly into the septic system. (See Chapter 6.)

Appliances such as clothes washers and dishwashers can be a problem. Most aren't designed with cottaging in mind (maybe there's a message there), little if any attention having been paid to the need for periodic draining. If the ap-

pliance has drain plugs (check your manual or disconnect the power and peek underneath with a flashlight), use them. Regardless, my advice is to disconnect the water lines and pour RV antifreeze (propylene glycol) into the incoming line. Then turn on the machine for just enough time to circulate the antifreeze through the nooks and crannies that invariably exist inside, and that should suffice.

PUTTING THE PUMP TO BED

While all the lines should now be empty, enough water can remain in the pump's innards to freeze and crack the casings, so this must be tended to as well. Although some folks leave the drain plugs out all winter, I always replace bolts and plugs and such so I know where they are next spring, and where they're supposed to go. Whether you replace or store them, putting a dab of vegetable oil on the threads of a plug will discourage rust from attacking the threads. (Avoid toxic greases anywhere in the drinking-water supply system.)

Hand pump: To rid a traditional hand pump (displacement variety) of water, push the handle

down, slowly, and then hold it in the down position to keep the bottom flapper open while the water drains out. You may have to wiggle the handle a bit, but you'll hear the water running out the bottom when you get it right. It's as easy as operating the pump.

Piston pump: A piston pump requires the most work to store. To drain the water box, undo the drain plug or plugs. (They're usually at the bottom of the box or on the bottom edge of a side, but check your manual if you can't find them.) However, if a piston pump is merely drained and then left until spring, the piston's seal and flapper valves may dry and become hard. This dramatically increases wear the next time the pump is stirred into action, making it more difficult to prime. And should iron be present in the water, scale can accumulate under the valves, making it necessary to take the pump apart and clean it before any water will reach the cottage taps.

To avoid such shenanigans, the owner's manual usually recommends pulling the piston out and storing the piston seal in liquid (such as linseed or vegetable oil) at the end of the season. A reasonable (and easier) alternative is to fill the empty water box with RV antifreeze (propylene glycol), which will protect it from freezing and keep the piston seals and valves soft.

Centrifugal pump: A centrifugal pump, such as a jet pump, requires draining only, usually via a plug in the bottom of the water box. Some pumps have a number of plugs, all of which must be removed to enable the water to drain out.

Submersible pump: A submersible pump can stay submerged all winter with no draining necessary, as long as ice conditions aren't severe enough to reach down to the pump, or pull at the attached intake line and take the pump for a ride. But the pump should be anchored in place as to allow some movement should the ice get nasty, otherwise it can be torn from its anchors. Should you opt to remove it, the water held by its impellers can freeze and break the pump, so the solution is to flush out the water by placing the pump in a narrow container of RV antifreeze and running it for two or three minutes.

THE UNFLOW CHART: QUICK STORAGE LIST

- Shut the power off to the hot water tank and use up the existing hot water.
- Shut the power off to the pump.
- Drain the intake line and store if exposed.
- Open taps and in-line valves and then drain the pressure lines, flushing the toilet to empty its tank.
- Drain the hot water tank, any water treatment devices, and the pressure tank if not a bladder or diaphragm type.
- Drain and, if necessary, store pump.
- Drain any appliances (washing machines, etc.), and add RV antifreeze.
- Drain waste drain traps, putting RV antifreeze only in those traps which cannot be drained.

WASTE LINES: ONLY THE TRAPS REQUIRE ATTENTION

Waste lines, the big ones that transport the used and abused water and miscellaneous bodily fluids out of the building, are naturally self-draining. Of course, there is always an exception, and in this case the drain traps are it. These are 180° elbows placed in the line just below open drains – such as sink, tub, and floor drains. The trap holds water continuously, forming an airtight seal within the pipe, thereby preventing fumes from venting back up the waste lines and into the building. Newer ABS plastic traps often have a drain plug at the lowest point of the elbow, making draining and cleaning out goop a simple task. Older metal traps may not have such plugs. Traps in toilets are built into the plastic or ceramic mould, accessible on a once-in-a-lifetime basis with a sledgehammer.

Drain traps under sinks are usually accessible from underneath, normally through the cupboard below the sink. Traps under tubs are often hidden behind ceilings, though open floor joists in basements and crawlspaces may provide access.

If a trap can be drained, by all means do so. An empty pipe won't burst from freezing no matter how cold it gets. (Again, I like to replace any plugs after draining so I always know where they are.) For traps without drain plugs, like those in toilets, RV antifreeze (propylene glycol) makes sense. Pour in only enough to replace the water with antifreeze. (The water has usually been pushed out when the liquid in the trap is the same colour as the liquid in the antifreeze container.)

OPENING UP: JUST REVERSE THE STEPS

Having completed all the necessary tasks of cottage storage – thereby greatly reducing the odds of discovering any unpleasant spring surprises, plumbing wise – we simply do an about face (sort of) to open up the cottage and reverse the

THE FLOW CHART: QUICK OPENING-UP LIST

- Connect the intake line, and test for the correct operation of the foot valve and any check valves before putting the line into the water (or connecting to a submersible pump).
- Prime the pump (cottagers with submersibles can skip this step).
- Turn on the pump, and flush out any device that wintered with antifreeze.
- Bleed out any air in the hot water tank before turning it on.
- Reactivate any water treatment devices and ensure that they are all operating correctly before drinking the water.

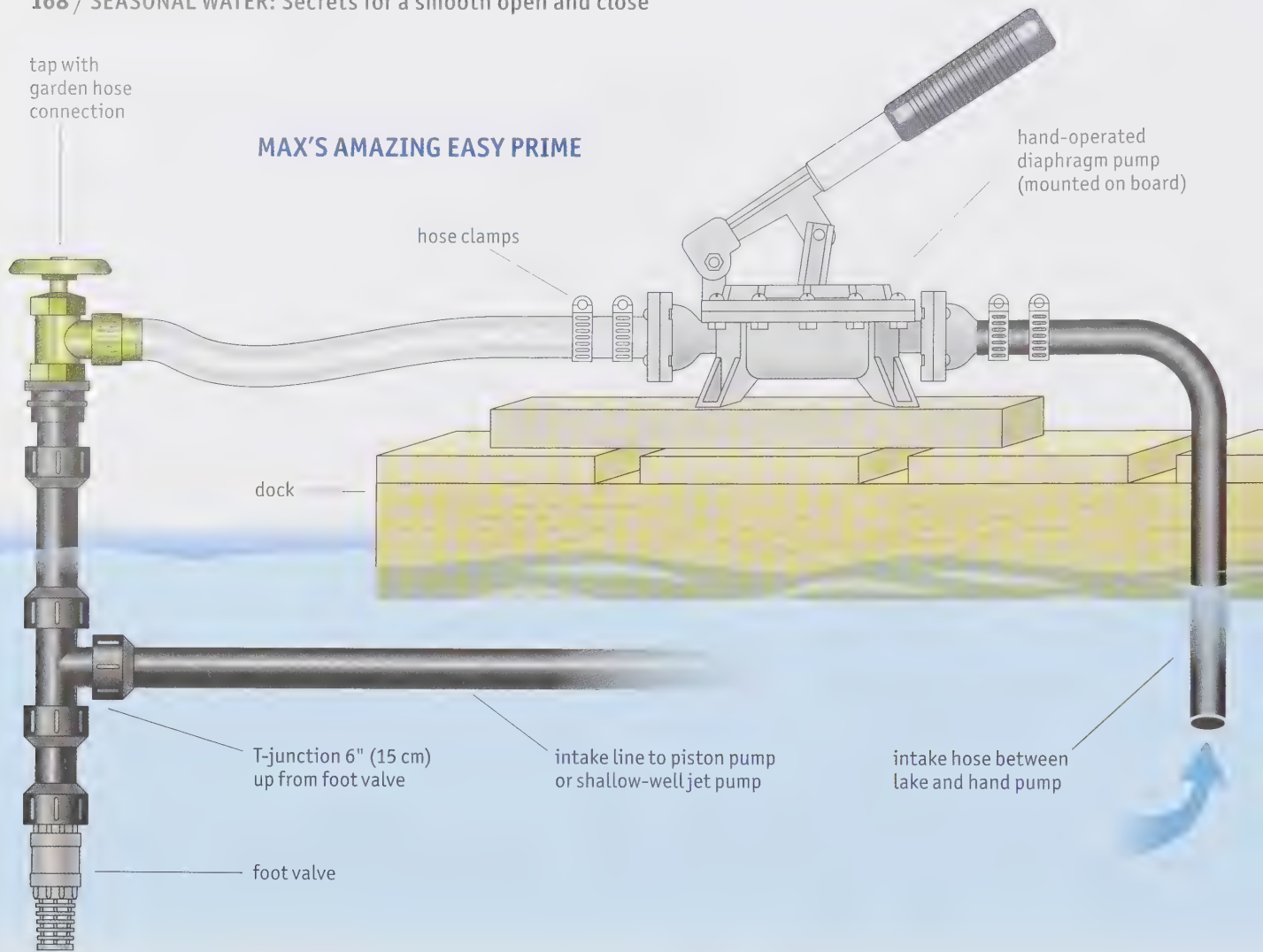
whole procedure. Fortunately for folks not proficient in reading backwards, the opening-up task is set forth below.

GETTING THE INTAKE LINE BACK INTO POSITION

If part of the cottage storage regimen included rolling up poly intake lines, it follows that part of the opening-up experience may include such frivolities as unwinding those great coils of uncooperative poly pipe, forcing cold, hard pipe onto couplings, fiddling with the sharp edges of hose clamps, and taking a moment to thaw frozen fingers so bandages will stick.

To ease some of the pain, lay the coiled pipe out in the sun for a while before attempting to make it lie straight and flat. You'll find plastic pipe a more agreeable substance to work with when it's warm. But those blasted barbed fittings are still a genuine hassle to force into the pipe. So spend the extra few dollars it takes to equip your intake lines with quick-disconnect fittings, such as those from Philmac and Hanflo. With a twist of the wrist and turn of a wrench, the joint is secure and leakproof.

Keep the ends of all lines capped until you're ready to make the connections. When it comes to sneaking into open pipe, sand and stones aren't particular about whether the line is being taken out of the water or put back in.



Get ready for prime time:

In this basic Easy Prime setup, a hand-operated diaphragm pump is used to push water to the household pump and interior plumbing. With the kitchen tap open, open the T-junction tap and operate the priming pump. When water comes out the kitchen tap, close the T-junction tap and the entire system is primed and ready for use.

Before tossing the end of the intake line down a well or into a lake or river, take a couple of minutes to verify that the foot valve and any check valves are indeed working (see Chapter 4). It could save hours of aggravation.

PRIME TIME: TRY "MAX'S AMAZING EASY PRIME"

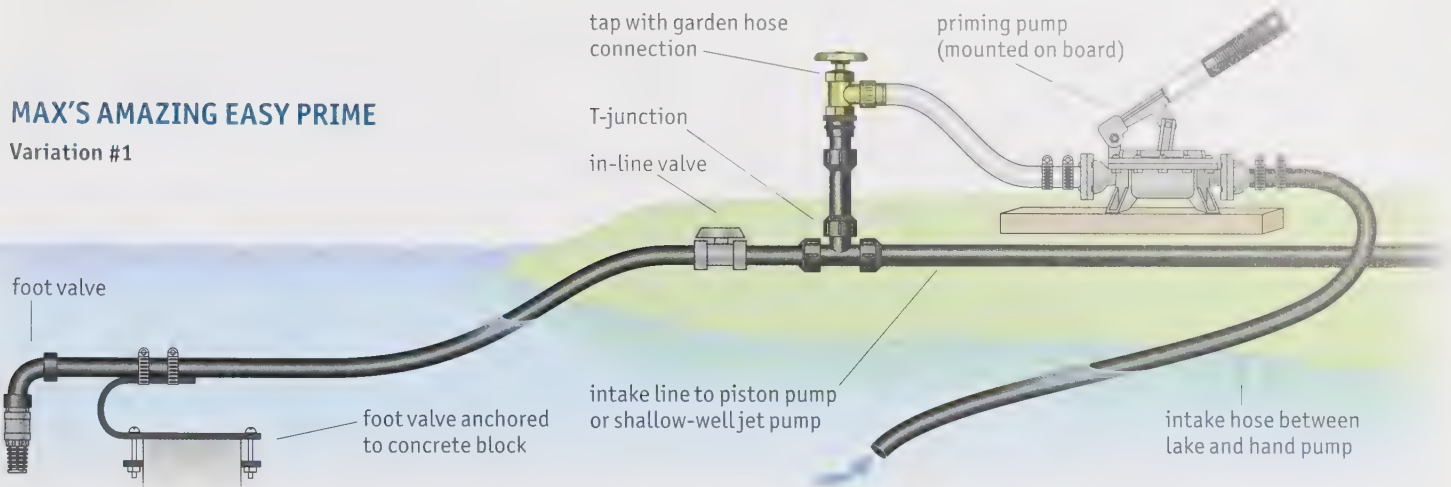
Traditional priming methods are masochistic: running bucket brigades into crawlspaces or pump houses is not considered to be a cherished activity by many, nor is fiddling with stripped

threads on priming plugs. For fast-acting relief from both, try "Max's Amazing Easy Prime."

With a piston or shallow-well jet pump drawing from surface water, splice a T-junction into the intake line about 6" (15 cm) up from the foot valve. If that's not convenient, install the T-junction approximately where the line enters the water – though the first option is preferable, as it will allow you to prime the entire intake line before starting the pump. Install a section of pipe about 1' (30 cm) long to the leg of the T, and then install a tap (herein referred to as a priming tap) suitable for a garden-hose fitting at the end of

MAX'S AMAZING EASY PRIME

Variation #1



A convenient connection:

Positioning the T-junction close to the foot valve is ideal, but if that setup doesn't work for you, simply move the junction up the line. By making the connection at the water's edge, you'll have dry and easy access to the tap.

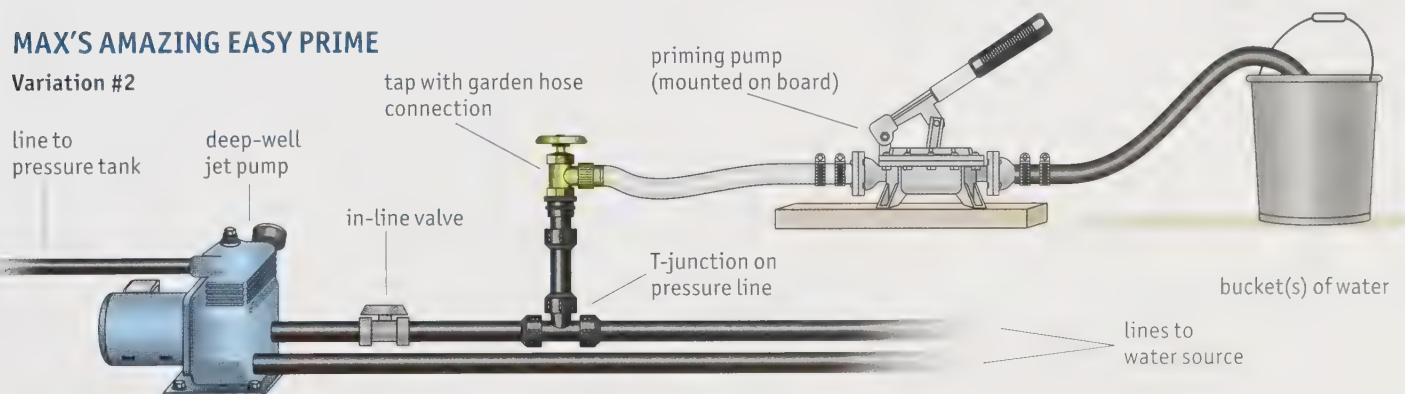
this pipe. In deep water next to a dock, a longer leg on the T may make priming easier

Come time to prime, you will need two short sections of flexible hose and a suitable portable priming pump. The preferred choice of priming pump is a hand-operated diaphragm pump (see Chapter 3), but a small drill-driven gear pump worth about \$100, and a portable electric drill (worth much less after you drop it into the lake) will also suffice. First, remove the pump's prime plug. If you own a piston pump and opted to take out the piston leather rather than fill the water box with antifreeze, you'll

need to replace the leathers too. Back outside, lift the intake line up alongside the dock (or boat) to expose the priming tap, attach a hose between the tap and the priming pump's discharge (using suitable hose clamps), and run the other short hose between the priming pump's intake and the water. Open the priming tap, and start pumping. When water comes out the pump's prime plug, turn the priming tap off and reinsert the prime plug. Disconnect the priming pump, drop the line back into the water, turn on the pump, then open a few taps to fill the indoor system. Now make yourself a cup of tea.

MAX'S AMAZING EASY PRIME

Variation #2



Deep-well jet pump configuration:

For lifts greater than 40' (12 m), install an in-line valve and a T-junction on the pressure line where it exits the pump. Open the pump's priming plug and close the in-line valve, then pump the pressure line full of water.

You can also reverse this procedure by installing the T-junction at the cottage pump and an inline shut-off valve between the pump and the pressure tank. Close the shut-off valve, then hook the hand-operated diaphragm pump up to the leg of T in reverse, so that it draws the water up through the entire length of the intake line to the pump. While this keeps you indoors and dry, it works best for shorter runs. For longer runs of intake line, say for 50' (15 m) or more, moving that handle on the pump requires some serious effort. It's always easier to push water with a pump than to rely on the meagre offerings of atmospheric pressure to do the job.

With shallow-well jet pumps or piston pumps, if a check valve is used on the intake line just before the pump instead of a foot valve at the submerged end, your choice of priming pump can be hooked directly to the end of the intake line for priming, no T-junction or priming tap required. Hold the end of the line under water when the priming pump is disconnected; otherwise the water in the line may drain back out.

For deep-well jet pumps, the T-junction should go between the foot valve and the Y-fitting housing the injector, the length and route of the pipe connecting to the priming tap adjusted to suit your particular situation. For well installations, because the priming tap will now end up at the top of the well, the much longer pipe leading to it will likely need an elbow or two to clear the walls of the well. The rest of the procedure applies as long as the lift is less than 40' (12 m).

A little more work is involved for deep-well jet pumps with lifts greater than 40' (12 m). First, install an in-line valve (a tap without a spout) on the pressure line (the smaller of the two) right where it leaves the pump, followed by the T-junction and tap. Run a hose between a hand-operated diaphragm pump's intake and a water source (lake, buckets, dug well) and connect the discharge side to the T-junction tap. Remove the pump's prime plug, close the pressure-line in-line valve (this forces the water to flow down the pressure pipe rather than into the pump), open the T-junction tap, and start pumping. As it requires about 1 US gallon of water to fill 10' of

1" poly pipe (1 L for 3 m of 1" poly), this could take a while if there is plenty of pipe between the pump and water source. When the water comes out the prime plug, reinsert it, close the T-junction tap, open the in-line valve, and the system is primed, first time, every time. (This method can also be used for lifts less than 40' or 12 m.)

With a bit of ingenuity, a priming pipe can even be run down into shallow wells (check with local authorities to make sure this is legal in your area), obviating the need to pull the line out for priming. Recently, on a well not equipped with a priming pipe, my Guzzler and I coaxed water up 250' (76 m) of 1" line, having a 10' (3 m) lift. With no prime. Now you know why I like hand-operated diaphragm pumps like the Guzzler.

Those blessed with submersible pumps need only open a tap and flick a switch for the pipes to fill with water. But look at how much fun they miss.

OUT WITH THE ANTIFREEZE

Regardless of pumps or priming techniques, if any antifreeze was used in the pressure lines during storage procedures, run the taps until it's flushed out of the system. Also, open the hot-water tank drain tap (or the kitchen sink's hot-water tap) just enough to bleed the air and ensure that the tank fills with water before you turn it on. Without water in the tank, the heating element could quickly burn out. To reactivate water treatment devices, check the appropriate manual. It may be necessary to have the water tested to ensure that the devices are working correctly.

Once the little bit of plumbing required to make priming easy is completed, this annual rite of spring is pared down to a task that takes minutes (instead of weekends). Only a leak in the intake line can cause it to fail, the odds of which are also reduced if the above procedures are followed.



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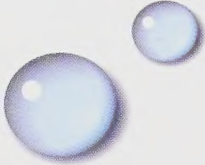
THE OBLIGATORY DEPRESSING ENVIRONMENTAL PLEA



Humans tend to be easily drawn into what are known as social traps. Social traps are similar in concept to animal traps, the victim (in this case, us) lured into the trap by some attractive bait. Like other species of animals, we do not notice or perhaps choose to ignore the trap surrounding the bait. For example, the bait may be a new boat or tractor which we can only afford to purchase if we don't fix the defective septic system that oozes effluent out onto our yard and from there into the watershed. The trap is the destruction of that water resource. In other words, our source of water for drinking, washing, irrigation, fishing, and all the pleasures of a late afternoon swim on a hot summer's day, becomes off limits, no longer suitable for use by humanity.

The trap is insidious by nature – few notice it has been sprung until it's too late. Yet each time one of us doesn't take the bait, chances improve that planet earth will still be a swell place to inhabit and enjoy next year, and in all the ensuing years.

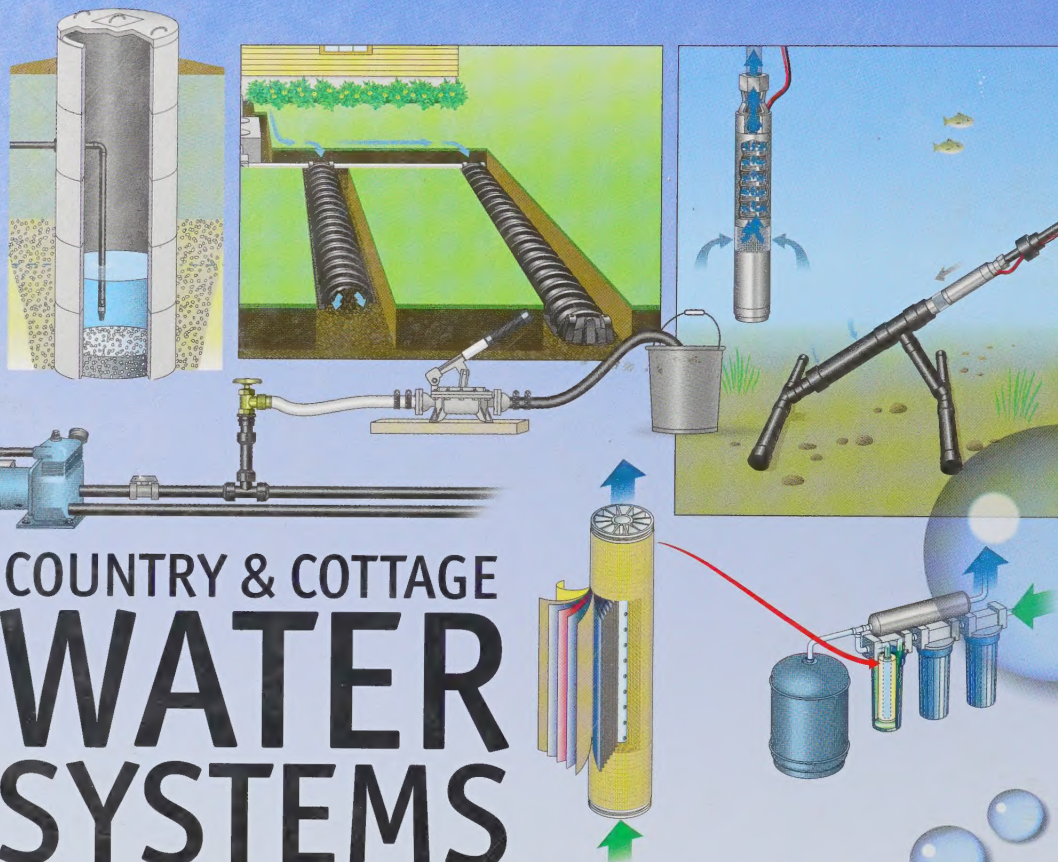
Beware of the traps.



IF YOU LIVE IN A RURAL AREA, OR SPEND TIME AT A WATERFRONT COTTAGE IN THE COUNTRY...IF YOU HAVE A PUMP, A WELL, OR A SEPTIC SYSTEM...IF YOU WINTERIZE YOUR WATER SYSTEM OR USE IT YEAR-ROUND...OR IF YOU SIMPLY CARE ABOUT THE QUALITY OF THE WATER YOU DRINK, THIS INDISPENSABLE GUIDE WILL SAVE YOU TIME, MONEY AND HEADACHES

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ISBN-13: 978-0-9696922-7-0
ISBN-10: 0-9696922-7-7



\$39.95

PRINTED IN CHINA

W7-AMV-635